JOURNAL

OF THE

ROYAL NAVAL SCIENTIFIC SERVICE

Vol. 29 ★ NOVEMBER 1974 ★ No. 6

RESTRICTED

Journal of the ROYAL NAVAL SCIENTIFIC SERVICE

Volume 29

Number 6

November 1974

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RESTRICTED

J.R.N.S.S. 1945 - 1974

CHANGE OF TITLE

After twenty-nine years of publication as

Journal of the Royal Naval Scientific Service

our Title is to be changed to

JOURNAL OF NAVAL SCIENCE

The first issue under this new title will appear in January 1975 and subsequent issues will be published at Quarterly intervals. The policy of the Journal in respect of both content and distribution is to continue unchanged and its pages will remain available to all those who wish to advance the knowledge of Defence Science in general and particularly so if such contributions bear upon the Naval scene.

THE DESIGN OF AN OMNI-DIRECTIONAL UHF WRAP-ROUND ANTENNA

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This article describes the development of an omni-directional UHF communication antenna, intended to be fitted around an encastré polemast. Stress is laid upon the requirement of r.f. linearity since each antenna may be required to support up to 14 simultaneous channels within the band.

Introduction

For the past 20 years, the standard UHF communication antenna used in H.M. Ships has been the vertical bi-cone antenna designated Type AJE and described in Reference 1. Although an adequate antenna in itself, it could not claim a position on a ship where it would command an uninterrupted " view " of the horizon, priority being given to other sensors. The several antennas required for transmission and reception were distributed around the masts and the resulting inter-action between these, together with reflections from the superstructure led to serious pattern degradation; some nulls in the horizontal radiation pattern being as much as 20 dB.

With the advent of multi-channel working it was decided to examine the antenna problem with a view to improving on the partial all-round coverage given by the existing system of antennas.

General Specification

(a) Bandwidth
225 - 400 MHz,

(b) Gain
Unity, relative to a half-wave dipole.

(c) Polarisation
Vertical.

(d) Horizontal pattern
Omni-directional within $\pm$ 1 dB to give all-round coverage to the ship's horizon.

(e) Vertical pattern
Approximately dipole pattern.

(f) Input impedance
50 ohms.

(g) V.S.W.R.
2 : 1 maximum each antenna.

(h) Isolation
Between transmitter and receiver antenna greater than 40 dB.

(j) Linearity
The r.f. impedance linearity to be such that with two test signals f_1 and f_2 where $f_2=f_1\pm10$ MHz or greater, the level of the third order product to be at least 120 dB below the level of either signal.

(k) Power handling
The antenna to be capable of handling a P.E.P. of a least 30 kW with a mean power of 1 kW.

(l) Weight
The polemast, antennas and feeders to be not greater than 336 lb.

(m) Environmental
As defined in Def. Spec. DEF 133.

(n) Accessibility
There would be no provision for servicing the antennas *in situ*, the whole polemast antenna assembly being shipped as one item. To increase the versatility of the antennas it was desirable to split them longitudinally to facilitate their fitment around encastré masts up to 10 inch diameter in other applications. There must be at least 1 inch clearance between the mast and the reflector of the antenna to allow for passage of cables to other antennas etc.

Design Considerations

An examination of the General Specification suggests the following essentials.

A high site for maximum horizon range and minimisation of reflections from superstructures; which would give rise to pattern distortion, inter-antenna coupling and possible inter-modulation.

The minimum number of antennas consistent with meeting the specification, in view of the scarcity of high sites.

Antennas with vertical dipole-type fields.

The basic physical essentials could be met with two wide-band dipole antennas, one for transmitting and one for receiving, mounted respectively on top of the foremast and the mainmast, the nominal spacing of 50 or 60 feet between masts being sufficient to obtain the required level of inter-antenna decoupling in this parallel configuration of antennas.

Topmast sites are hard to come by, and the alternative linear configuration on a single mast has to be considered. A separation of around 7 feet between antennas in this configuration is considered sufficient to obtain the level of decoupling required in the specification. This separation is realisable on the polemast which is generally fitted on one of the two masts of most frigates to carry the HF d.f. antenna where there is, in most cases, some 12 feet of usable pole surface.

The co-linear alternative of course requires that the individual antennas have to be in the nature of circular arrays of dipoles, to provide omni-directional coverage in the presence of the polemast, instead of the single dipoles of the parallel arrangement. Encircling the mast with dipoles complicates the antenna design but would appear to be the best approach in the circumstances.

To minimise direct coupling *via* the pole also to minimise radiation from the pole which could possibly give rise to pattern deterioration and inter-modulation effects, some form of reflector would be necessary between each antenna and the pole. Such a reflector would have the added advantages of making the antenna largely independent of polemast external irregularities and would allow a single design of antenna to be fitted to various diameters of polemast. A cylindrical reflector completely screening each antenna from the pole is the obvious choice.

Since the impedance bandwidth of a dipole increases with decreasing aspect ratio, plate dipoles are the natural choice and these could be curved to form an overall cylindrical outline to the radiators to give a constant radiator-reflector spacing.

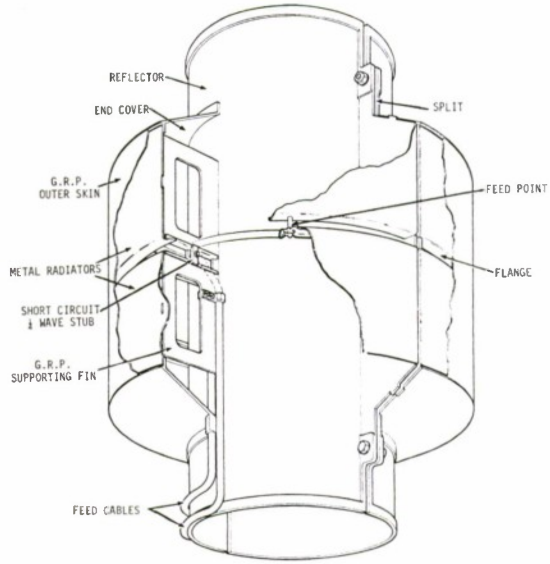

FIG. 1. Sectioned drawing of wrap-round antenna.

Flat plate dipoles with aspect ratio near unity will give the radiation pattern bandwidth to satisfy (a), in the chapter headed General Specification. The gain and vertical pattern requirements (b) and (e) are met by the dipole/reflector arrangement. The impedance of this arrangement could, however, be on the low side but if the plates are folded into the reflector to give folded dipoles this would help to obtain the 50 ohms impedance using multi-feed points.

Early experiments with folded dipole configurations showed, however, that it was difficult to obtain the requisite order of isolation to satisfy (h) and it was eventually decided to concentrate on dipole radiators backed by a reflector with impedance transformation in the feed network. The design approach towards obtaining an acceptable V.S.W.R. over the band, was to attain a 2 : 1 match to 50 ohms of the individual radiators and then transform the resultant impedance of the array to that of the 50 ohms feeder.

Examination of the resistive component of the impedance of a simple dipole and reflector (Fig. 3) shows that the spacing between reflector and dipole to give a resistive component of 25

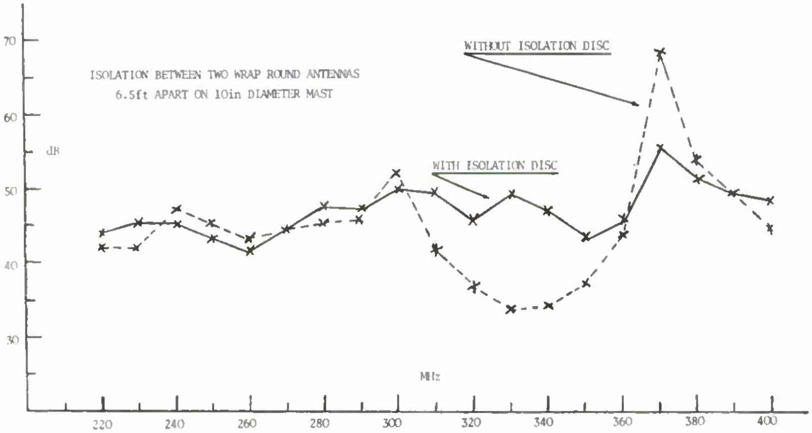

FIG. 2. Antenna isolation.

ohms should be of the order of $0 \cdot 12\lambda$. If we fix the diameter of the reflector at 12·5 inch to allow for cable clearance (n), the pitch circle diameter of the radiators at mid-band should be around 21·5 inch which is a convenient size to accommodate four radiators and feeds spaced a little more than a half-wavelength at the highest frequency. This parameter meets the circular pattern requirement (d).

These considerations give rise to the form of antenna depicted in Fig. 1.

Prototype Antenna

Impedance

Based on the above considerations a laboratory model was constructed in such a way that various parameters could be readily adjusted. By the application of shunt stubs across the halves of each pair of radiators at a distance of approximately $\lambda/4$ from the feed point at mid-band frequency (Fig. 1), the extremities of the terminal impedance plot were brought in to obtain a V.S.W.R. of better than 2 : 1 over the band (Fig. 4).

Radiation Patterns

It was found that the circularity of the azimuth patterns was affected by the setting of the tuning stubs and the best pattern circularity did not quite coincide with the best impedance plot, so that the final choice of stub length was a compromise giving a circularity of better than ± 1 dB over the band.

By itself, the antenna gave smooth dipole-type patterns in the vertical plane and, as might be expected, the vertical patterns were to some extent distorted when a mast was inserted within the reflector (Figs. 5, 6, and 7). These distortions are due to residual currents on the mast surface resulting from the restricted length of the reflector necessitated by weight considerations.

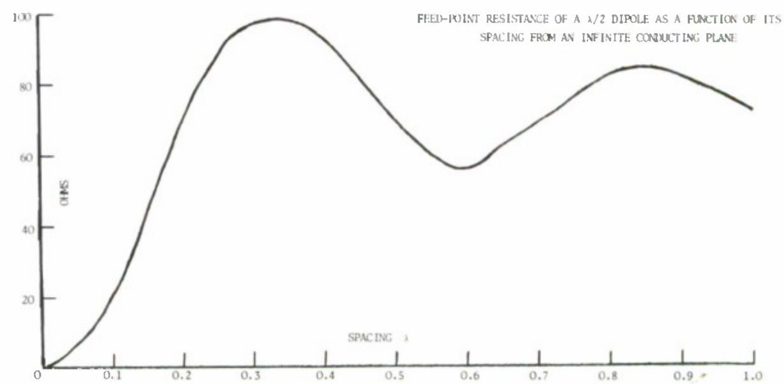

FIG. 3. Resistance of a dipole with reflector.

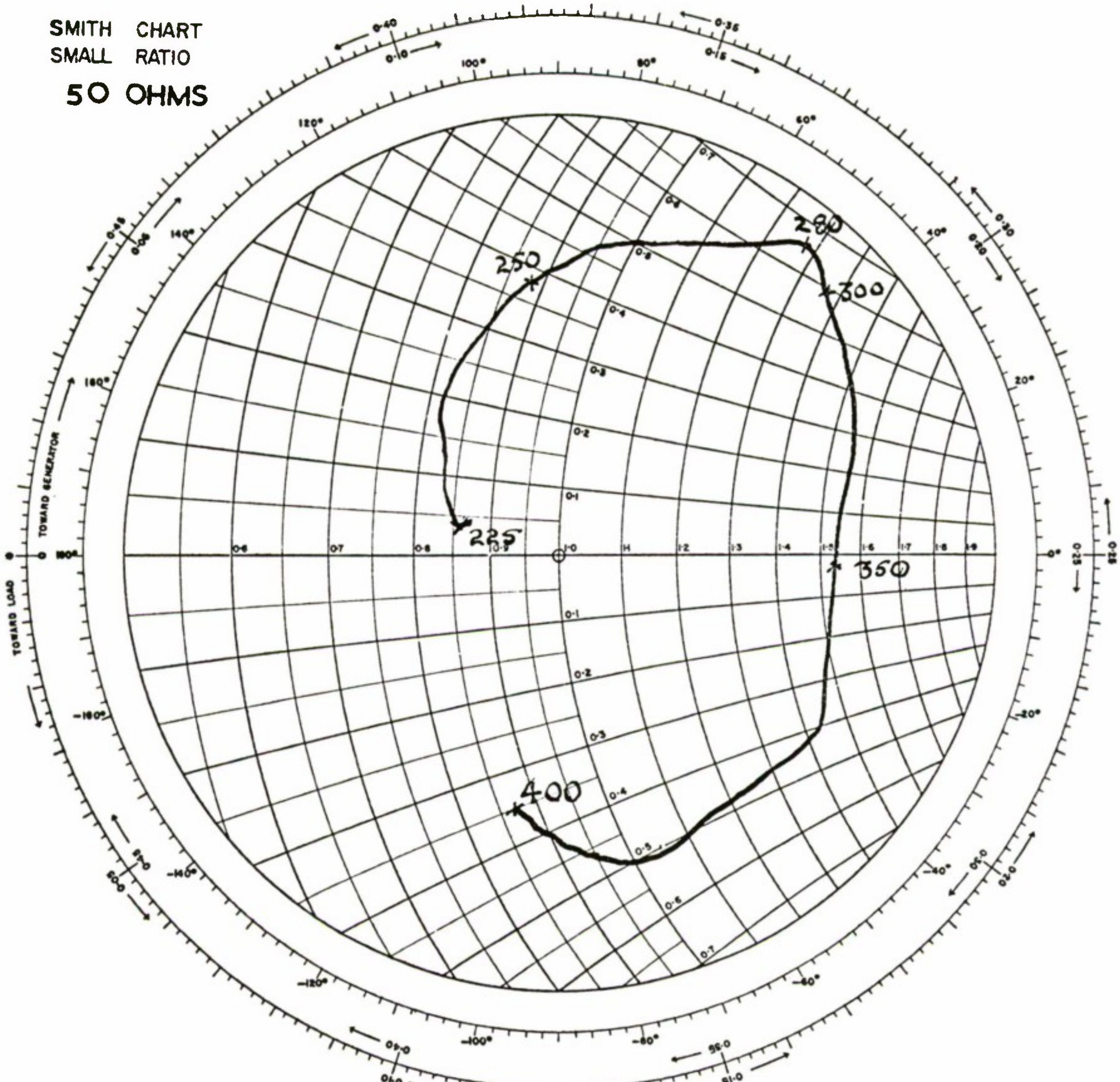

FIG. 4. Impedance plot complete antenna.

Isolation

Within the confines of the polemast—a navigation radar at the lower end and a HFd.f. at the top — the spacing of the wrap-round antennas on the mast was restricted to a maximum of 6·5 feet centre to centre. This resulted in the isolation curve shown dotted in Fig, 2. Experiments with various size discs placed centrally between the two antennas, showed that a minimum diameter disc of 30·5 inch was required to give the 40 dB isolation necessary (full line curve in Fig. 2).

Transformer

The four 50 ohm dipoles when connected in parallel give an impedance of 12·5 ohms. As a 50 ohm feeder is used to connect to the antenna, a step-up transformer has to be incorporated. To cover the 1·8 : 1 band requirement, the transformation was carried out in three stages and, using Tchebycheff techniques, this should give a theoretical V.S.W.R. of better than 1·04 over the band. The feed end of the transformer was fitted with a standard E.I.A. flange and the other end with a four-way

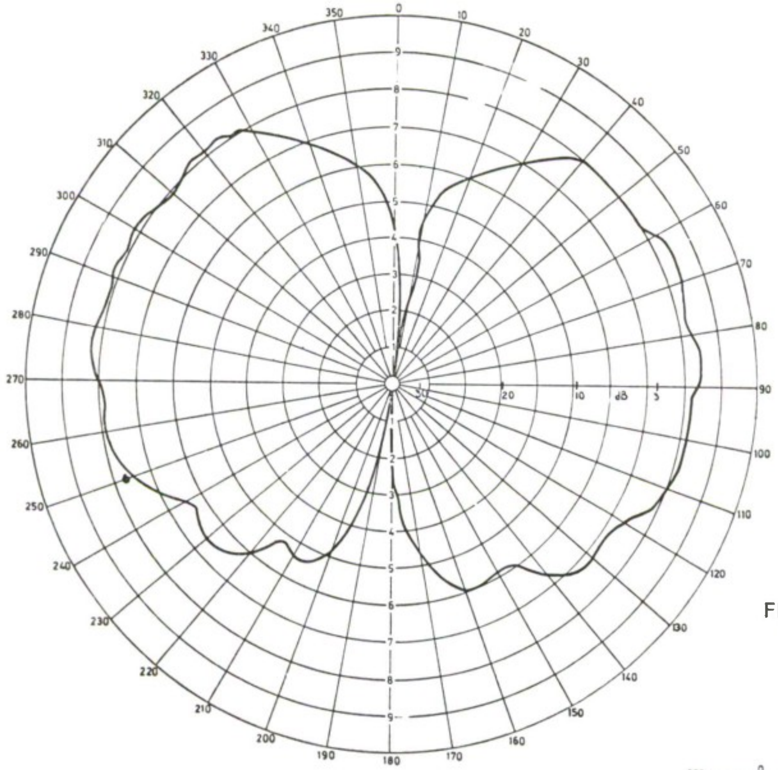

FIG. 5. Vertical radiation patterns.

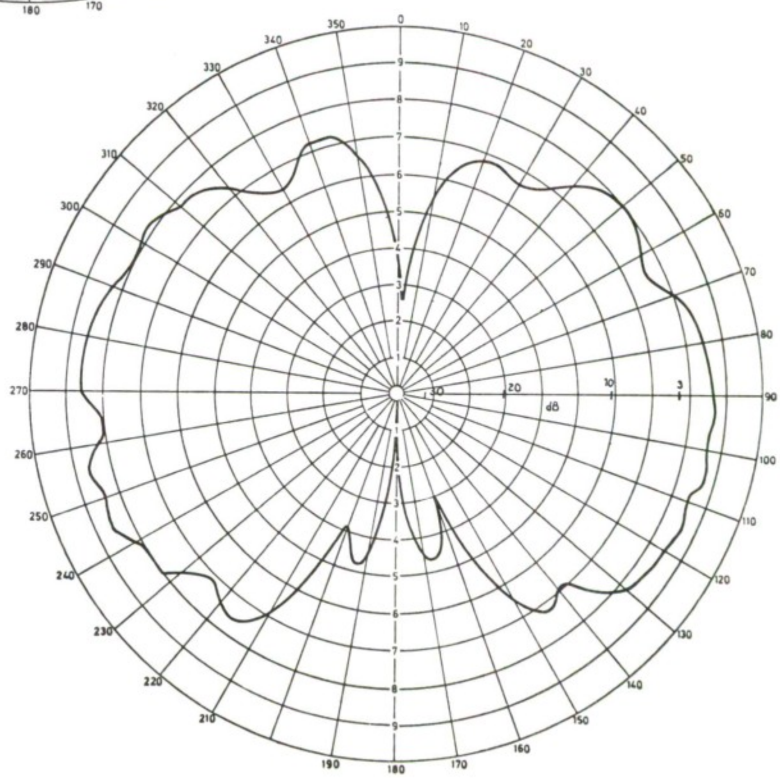

FIG. 6. Vertical radiation patterns.

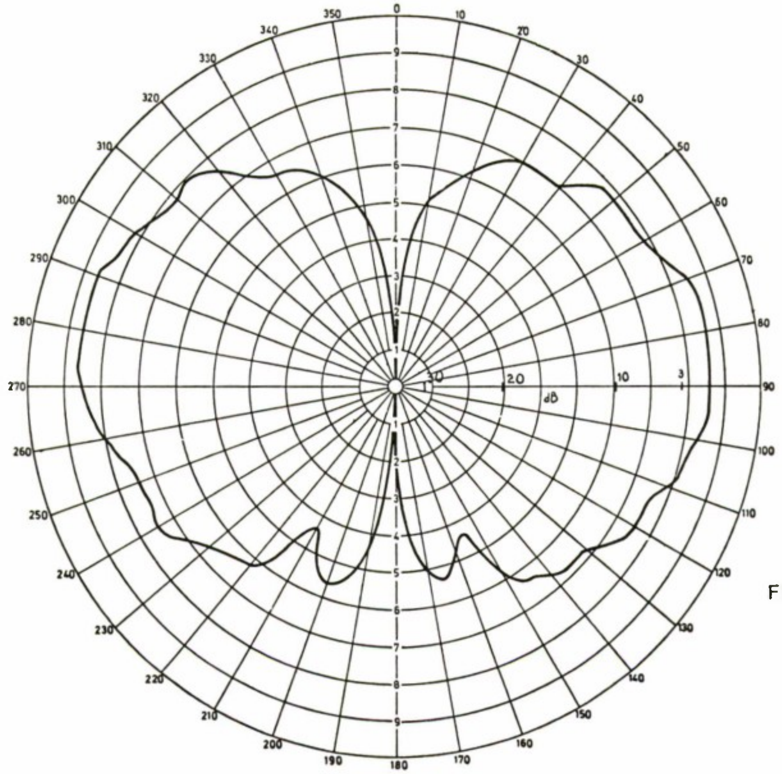

FIG. 7. Vertical radiation patterns.

was co-linear to the transformer with the four feeds coming off radially at right-angles. Although this is a reasonably simple device to match, the cable take-off bights to the elements would force the transformer away from the mast causing location difficulties. The final design of splitter was placed at right-angles to the transformer so that the feeds came off in the same plane as the transformer. This presented matching difficulties because of the violent change in the symmetry of the system. Without matching sleeves, the transformer plus splitter V.S.W.R. was better than 1·2 and after matching, better than 1·06. The matching sleeves were made from P.T.F.E. to cover breakdown requirements.

Linearity

Fig. 8 shows the arrangement of the linearity test site. Two transmitters Type 692/693 delivering frequencies f_1 and f_2 at 20 watts each, are fed to a common junction *via* triple-tuned cavities tuned to these frequencies. From the junction, $f_1 + f_2$ are then fed *via* 180 feet of buried $\frac{1}{2}$ inch air-spaced, flexible, solid-outer cable to the object under test. Any non-linearity in the object will create the third order intermodulation (i.p.) $2f_1 \pm f_2$ (this is the i.p. of the largest amplitude). The frequencies of the transmitters are therefore chosen so that f_1 f_2 and the i.p. frequency lie within the 225 - 400 MHz band. On reflection the i.p. will return to the common junction and will enter the third triple tuned cavity which has previously been tuned to the i.p. frequency. The receiver used had a sensitivity of 1 microvolt which is 150 dB down on 20 Watts at 50 ohms which adequately covers the antenna specification of 120 dB down on 20 Watts. Because the layout of the active and passive components necessitates the use of a number of connectors each of which could produce non-linearity, it is well to have a reference standard to check the system each time it is used. During the period of the linearity check on the wrap-round antenna, such a standard was available in the form of the all-copper version of the aluminium antenna Type AJE (see Introduction). This version is designated UK SAR 102 and has a linearity greater than 150 dB.

Four wrap-around antennas were checked and each has an i.p. greater than 135 dB. This high order of linearity was achieved by careful detail design:

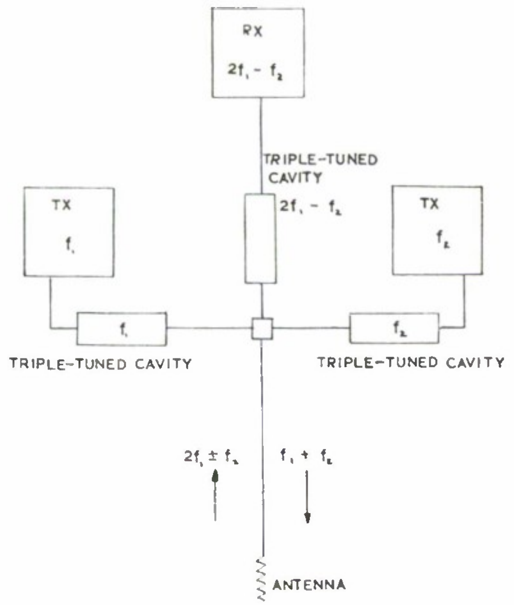

FIG. 8. Linearity test site.

(a) Wherever possible, copper was used in manufacture so that there was a continuous run of similar metal from transmitter to antenna radiating surface.
(b) Adjoining surfaces were brazed or hard soldered.
(c) The demountable joints of the four-way splitter of the transformer were made as compression joints.
(d) All sharp edges were removed or varnished with epoxy resin.
(e) Cabling was made in solid copper outer sheathing (as opposed to braided sheathing) internal and external to the antenna.

As a matter of interest, Fig. 9 shows the result of placing a resonant dipole with a diode across its input, in the field of the reference antenna when the antenna is in the load in the i.p. site. The curve shows the influence of an asymmetric junction on antenna linearity at quite large distances.

It will be evident from this why it is highly desirable to use a linear reflector to minimise antenna currents on the mast, the latter being of steel construction and a possible source of non-linearity.

Mechanical

One of the requirements for this antenna was that it should be capable of being fitted to existing built-in polemasts. This meant that the antenna would be manufactured and supplied in two longitudinal halves which were individually waterproofed, causing a break in continuity of the copper surfaces of the antenna of some $\frac{3}{8}$ inch (see Fig. 1). This was accommodated by a difference in the settings of the pairs of short circuiting stubs and accounted for some of the problems leading to the compromise between V.S.W.R. and pattern circularity. Because of possible manufacturing tolerances, the stubs were left adjustable for the first four factory made antennas. It was found on acceptance checking that all stubs (taken as pairs) needed the same adjustment. This means that all future antennas will be manufactured with fixed stubs so obviating the need for sophisticated test equipment at the factory.

Since copper had to be used throughout the feed and radiator system and since the weight of the antenna had to be kept to a minimum, the large elements forming the radiating surfaces had to be made of thin (26 swg) copper.

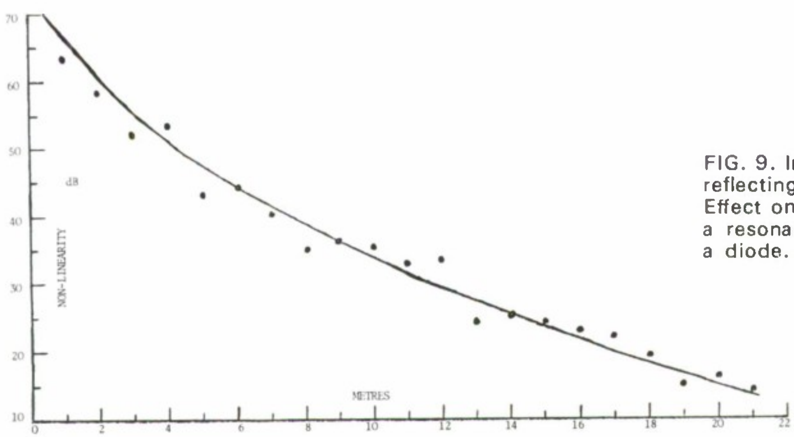

FIG. 9. Influence of a non-linear reflecting object.
Effect on a linear antenna of a resonant dipole shunted by a diode.

This metal was then embedded in G.R.P. to form a laminate which supplied the necessary mechanical rigidity and weather protection.

The internal reflector was manufactured from G.R.P. tube and sprayed with zinc to form a very light but strong reflector.

Except for making the inner conductor of the transformer from tube there was no way of lightening this item which weighs 8 lb.

The weight of the antenna alone is 46 lb.

Conclusion

The Specification Requirement has been adequately covered by this antenna and the methods of obtaining impedance and pattern bandwidth as described may be of use in the design of larger multi-element arrays.

Four antennas have been made to date, two of which have been used on a trials-ship pole-mast. Results obtained have been very satisfactory, there being only a slight deterioration in the antenna's omni characteristic due to its siting.

Reference

(1) "The Design of an Omni-Directional Aerial System for the Frequency Range 225 - 400 Mc/s.", by F. A. Kitchen. A.S.W.E. Technical Note CX-51-3.

A Sea King Helicopter lowers its Sonar during air training exercises with H.M.S. *Ark Royal* in the Mediterranean.

THE OPERATION OF THE SRN3 HOVERCRAFT AT THE INTERSERVICE HOVERCRAFT (TRIALS) UNIT

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Admiralty Experiment Works

After attending Gosport County Grammar School, **Brian Russell** commenced a sandwich apprenticeship with the de Havilland Aircraft Company Ltd., Portsmouth and Portsmouth College of Technology, during which time he obtained a Higher National Diploma in Mechanical Engineering. He then entered Government service at AEW Haslar as an Assistant Experimental Officer and assisted contractors in commissioning the electronic control system of the wavemakers in the Haslar Manoeuvring Tank, eventually becoming responsible for their operation. During this period he obtained a Higher National Certificate in Electronics. Then followed a two-year period on ship trials.

Early in 1967 the author joined the Interservice Hovercraft Trials Unit at H.M.S. *Daedalus*. He was promoted to Experimental Officer in 1971.

FIG. 1. SRN1 Hovercraft at sea.

Introduction

With the first practical demonstrations of a man-carrying hovercraft (SRN1 — Fig. 1) during 1959 and 1960, the military potential of this revolutionary new vehicle became evident. Accordingly in 1961 an Interservice Hovercraft Working Party was set up, and one of their first actions was the establishment of the Interservice Hovercraft Trials Unit at H.M.S. *Daedalus*, Lee-on-the-Solent in February 1962. The Unit's initial task was the evaluation of hovercraft built by the emerging industry. The SRN3 hovercraft—the subject of this article—was the first purpose-built craft ordered for the Unit.

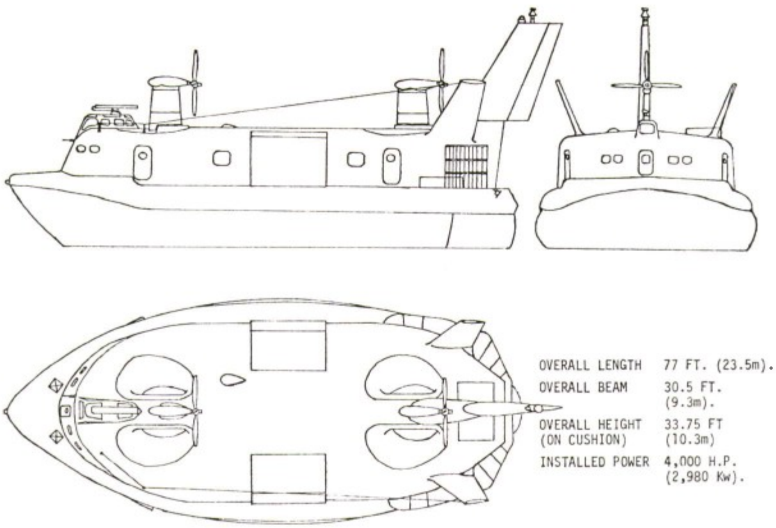

FIG. 2. General arrangement of SRN3.

The Hovercraft Principle

Before describing the SRN3, the principle on which a hovercraft operates is briefly described. As may be seen from a study of patent applications, thought had been given over many years to the reduction of ships' hull friction by the use of air between the hull and the water. But it wasn't until the experimental work of Sir Christopher Cockerell in 1954 that the hopes of so many inventors achieved practical fulfilment.

Sir Christopher showed that by directing a jet of air downwards around the periphery of a craft, a region of pressurised air—the cushion—could be formed such that the hull was lifted completely clear of the surface. This lift air could be pumped by a fan with much less power than that required by a helicopter or aircraft for free vertical lift.

SRN 1, when launched in 1959, was the first man-carrying craft to successfully embody this principle. Originally the peripheral air jet emerged from the lower part of the metal hull, but the hull clearance was later increased by the addition of flexible structures—' skirts '—to improve overland obstacle crossing capability and performance in waves. The skirts can be clearly seen in Fig. 1. Thus by the time that a purpose-built service craft was required, all the major requirements for a viable form of amphibious transport had been satisfied.

Description of SRN3

The keel of SRN3 was laid down in August 1962. She was to be a highly manoeuvrable multi-engined, amphibious craft, with a calm water/still air speed of over 70 knots, suitable for evaluation trials by all three services. The maximum operational weight of the craft was 39 tons, of which 13 tons was disposable against fuel, payload and special equipment.

As shown in Figs. 2 and 3, propulsion was by two air propellers, each mounted over the bifurcated intake of a lift fan. Control was effected by rotating the propeller pylons, the aft central fin and rudder being slaved to the aft pylon. The pylons could be operated in two ways to provide either a sideforce or yawing movement as required.

Power was provided by four marinised gas turbines of the Gnome series, developing a total of some 4,000 h.p. The engines were mounted in geared pairs, driving forward and aft propeller/fan systems. The craft was unique amongst hovercraft operated at IHU in that operation of the engine throttles was the responsibility of the craft engineer and not the pilot.

The craft was steered from the front seat in the upper forward cabin; the rear seat being intended for the craft Commander. Engineer and navigator/radio operator sat at the main deck level forward and below the control

cabin. Amidships was a sizeable loading bay, external access to which could be gained using the two hydraulically operated loading doors. These doors also served as vehicle or equipment loading platforms when the craft was operating in the logistic role.

SRN3's Trials Career

In the course of her trials career, between handover on 2 June 1964 and her last sortie on 21 February 1974, the craft executed 570 sorties, completed 1,393 operating hours and covered an estimated 40,000 nautical miles in German, Danish and U.K. waters. Despite what may seem to be rather limited operating hours within the span of nearly 10 years, she amply satisfied the objectives for which she was built. She laid the foundation against which subsequent craft have been developed for more specific roles. SRN3 was an experimental machine, and as such was not without her problems.

Role Evaluation Trials

After the initial crew training a series of role evaluation trials were conducted for all three Services.

These commenced with one of the few trials conducted specifically for the Royal Air Force and involved an assessment of the ability of the SRN3 to perform the duties of an R.A.F. Marine craft. The first Royal Naval trials were in Anti-Submarine Warfare (ASW) and involved the use of a dunking sonar to locate submarines in the area off Portland Bill.

It was perhaps during the first Army trials carried out in October 1964 that the craft initially demonstrated her real capabilities. These trials involved operation in the logistic role in transporting equipment and men from ship to shore. In three separate sorties SRN3 carried in turn: 50 fully equipped troops around the Isle of Wight in calm conditions, at an average speed of 48·6 knots; four Long Wheel Base Land Rovers (LWBLR) from Lee to Thorney Island at an average speed of 57 knots and two LWBLR and 54 passengers.

Between June and August 1965 the craft was again exercised in the ASW role, this time based at Londonderry. During this trial the problems of skirt maintenance and its bearing on craft availability became really apparent, 68 per cent of the maintenance time being spent on skirt repairs. Another significant limitation demonstrated for the first time was the poor sea keeping capability of the craft, largely attributable to the ship-like bow shape.

FIG. 3. SRN3 Hovercraft.

If poor sea keeping was one of the disadvantages of the SRN3, then high speed for low installed power in calm conditions was one of her distinct advantages. This was well illustrated on 29 April 1966, in a comparative trial with the FPB *Brave Swordsman*. Acceleration and emergency stopping performance was comparable but at full power—4,000 SHP SRN3 and 10,500 HP FPB—SRN3 achieved 54 knots and *Brave Swordsman* 49 knots.

Shortly afterwards the craft showed off another of her advantages — high work-load capacity—in the NATO Exercise "Wooden Waggon", on May 6, 1966. In five crossings of the River Weser a total of 291 fully equipped troops and four LWBLR were carried and landed dry shod. Because the craft could cross mudbanks and islets the journey distance was only six miles, compared with the 20 miles that the LCTs employed on the same task had to travel.

The last role evaluation trial was conducted during September and October 1968, the craft being based at Shoeburyness for Fishery Pro-

FIG. 4. SRN3 returns to IHU for the last time.

tection Duties, when the craft's high speed in calm conditions and limited sea keeping were again highlighted.

During this trial, on September 18, 1968, the craft had been to inspect a diversion site at Weybourne Camp and having found the site unsuitable had returned to Great Yarmouth. Underside damage was suspected as constant bilging of the buoyancy tanks was required. In addition a hydraulic failure had rendered the fin unserviceable.

The weather forecast was favourable for the 19th, so it was decided to make for Shoeburyness where the craft could be jacked for inspection. Off Great Yarmouth 0·9 m. to 1·2 m. seas and 15 knots of wind were encountered and the craft could not stay above hump on the heading for Shoeburyness. H.M.S. *Wasperton* (Coastal Minesweeper) took the craft in tow, initially in the boating mode but finally in the hover to reduce the incidence of " slamming ". As the weather was deteriorating it was decided to divert to Harwich and moor up for the night, at 2300 hours, SRN3 having 2½ hours fuel left.

On the 20th, *Wasperton* was holed when attempting to take SRN3 to a berth in Force 6 winds. The craft then made her own way to a harbour buoy. On the approach to this buoy the main engines died in turn, the last one just as securing was commenced. It was not until a later inspection that it was realised just how lucky an escape the craft and crew had experienced. The remaining fuel had been over-estimated by some 30%, and the remaining 500 gallons was heavily contaminated with sea water.

Equipment Trials

In mid 1966 a series of trials was commenced to assist in the development of the Sealane navigation equipment currently fitted in IHU's BH7, a craft built specifically to continue with Naval Evaluation Trials. These trials mainly consisted of evaluating the Blue Orchid and Decca 71 helicopter dopplers in the hovercraft environment, They enabled the optimum aerial position to be determined and during accuracy checking runs the ability of SRN3 to maintain heading coincident with track under crosswind conditions, by vectoring propeller thrust, was particularly useful. These trials culminated with limited tests on the full Sealane equipment. Fig. 3 is a photograph taken during this trial, the D71 aerial being seen at the stern of the craft.

Performance Trials

A unique trial feature of the SRN3 was that on one occasion in November 1964 both air and water propulsion systems were fitted. Schottell units were attached at the craft quarters enabling a speed of four knots to be achieved in the boating mode.

Performance trials were carried out during the life of SRN3, initially under a joint programme operated by RAE Bedford and AEW Haslar. During these trials the heave stiffness and hovering efficiency were evaluated and craft sea keeping quantified. Even in seas of 0·6 m. to 0·9 m. the craft motion was such as to cause crew discomfort, particularly to the engineer, pilot, navigator and radio operator who were located close to the bow of the craft, On into sea headings buffeting became severe enough to cause damage to skirt components.

The maintenance load on the original skirt had been high and skirt development included the fitting of a combination skirt, where the lowest parts could be readily replaced. This was commenced in October 1966 but was not a successful exercise, due mainly to skirt bounce and overwater handling problems. The former was alleviated by fitting deep diaphragms in the skirt, but attempts to solve the overwater handling problems did not meet with complete success. These problems introduced a new term to the hovercraft performance field :" Slurping ", which has sometimes been described as " riding on top of a tall jelly '. This phenomena was particularly prevalent on down wind headings and together with uncomfortable rolling on cross wind headings resulted in an " unsafe " feeling and a high incidence of sea sickness in a well seasoned SRN3 crew. In August 1968 the original jet skirt was refitted to enable the craft to continue its trials programme, the higher maintenance load being accepted.

In 1969 - 70 a model correlation trial was conducted, the full scale tests being undertaken by IHU and model tests and subsequent correlation analysis being undertaken by British Hovercraft Corporation, the craft's manufacturers. The full scale tests were completed, but problems in making the model truly representative of the full scale craft together with financial constraints prevented the correlation from being completed,

Demonstrations

Those present at " Hovershow '66 " or those who have seen films of that event will remember

the impressive sight of SRN3 leading a formation of hovercraft on to Browndown and disgorging troops and vehicles in a mock attack.

This was only one of many demonstrations given to military and civilian personnel from many countries, the most recent of which was again at Browndown in June 1972 for delegates from CENTO.

It was whilst travelling through the Kiel Canal in May 1966 from Bremerhaven to demonstrations in Copenhagen that SRN3 achieved a certain notoriety. After protracted negotiations it was agreed that the craft could proceed through the Canal at 25 knots. When the Canal Pilot on board was told that at high speed the craft produced very little wash he agreed to an increase in speed to 40 knots. In fact the Canal passage of 52 nautical miles was achieved in 1¾ hours and a certain amount of consternation was caused to other users. *It is not known if the Canal Pilot retained his job after what must be the fastest transit through the Kiel Canal!*

Recent Trials

Most trials conducted during the last four years at IHU have been associated with the evaluation of hovercraft in the mine counter measures (MCM) role. The hovercraft has two main advantages which make it particularly suitable: low underwater signatures and relative invulnerability to underwater explosions.

SRN3, along with the other hovercraft based at IHU, has played an important part in this evaluation. In mid 1972 she was modified to enable the deployment and recovery of Dan Buoys to be carried out. The modifications consisted of mounting a gantry, hydraulic winch, hand rails and stowage arrangements for three Dan Buoys at the bow and the addition of a small platform just aft of the port ramp.

The Dan Buoys, moorings and ground tackle (sinker plus anchor) were carried in the main cabin. Just before the drop position was reached, the port ramp was lowered and the Dan Buoy placed on the ramp with the sinker and anchor on the platform just aft of the ramp. On an instruction from the craft navigator, the Dan Buoy and ground tackle were manhandled over the side as the drop point was reached. Recovery was achieved over the bow of the craft using the gantry and hydraulic winch, the Dan Buoys and ground tackle being stowed on the bow during the return to base.

In October 1972 a trial to investigate the ability of the craft to maintain a track when towing a drag load and using various control options was started. Prior to the trial the static and excess thrust up to 30 knots was measured. The drag loads selected were chosen to absorb three-quarters of the excess thrust at the speeds of interest. This trial terminated in November 1973 and the craft was prepared for its final trial.

It has been mentioned in an earlier paragraph that the relative invulnerability of hovercraft to underwater explosions offers a significant advantage over conventional craft in the MCM role. From earlier trials conducted by NCRE a response theory had been developed which required confirmation by data from a more representative craft in terms of size and structure. It was therefore decided to execute a series of shock trials using the SRN3. Two of the main engines, all portable equipment and any items that might be usefully employed as spares for other IHU craft were removed. The radio, radar and one auxiliary engine were retained on the craft and instrumentation to monitor the effect of the underwater explosions was fitted.

Although the craft was not expected to return to base after the last and most severe explosion she did so. In fact the last half-mile or so on to the IHU slipway was executed under her own power (Fig. 4).

It was hoped to preserve the craft in one of the museums specializing in vehicles, but unfortunately this proved impractical, and like many unique craft before her, SRN3 " has gone to the breakers yard ".

Epitaph

There are perhaps two epitaphs that spring to mind. The first is " We learnt a lot from SRN3 ". We learnt that for good seakeeping qualities hovercraft should *not* have a ship-like bow. We learnt that attention must be paid to skirt design if optimum performance and low skirt maintenance load is to be obtained. We learnt that a hovercraft can be successfully employed on a multiplicity of tasks for all three services.

But the epitaph I prefer is " Triumph through adversity ". SRN3 became known as " Queen of the Solent ", the name conferred by the many Interservice crews who have worked on her during her period at IHU. Above all else, this indicates the affection in which the craft was held. Perhaps this affection and the resultant *esprit de corps* amongst the SRN3 crews was attributable to the fact that in spite of

the many serviceability problems that often resulted in the execution of emergency repairs at sea, SRN3 usually managed to get home "under her own steam".

Right up to the end of her life, SRN3 demonstrated her high speed capability. On one of her last trips with only two main engines fitted she maintained a speed of around 40 knots. It is perhaps appropriate that the last entry in her log reads:

Operating times

Lift off	*Set down*	*Sortie time*	*Post sortie report*	*Craft state*
0730	1430	7.00	DCO* RIP	U/S

*Detail carried out

LAUNCH OF H.M.S. *ALACRITY*—SIXTH TYPE 21 FRIGATE

H.M.S. *Alacrity*, sixth of the Royal Navy's type 21 Amazon class frigates, was launched by Lady McKaig, wife of Admiral Sir Rae McKaig, U.K. representative of NATO's Military Committee, on 18 September at the Glasgow shipyard of Yarrow (Shipbuilders) Ltd.

The 2,500-tons Amazon class of ship was designed as a collaborative venture by Vosper Thornycroft Ltd. and Yarrow.

H.M.S. *Alacrity* is 384 feet long, has a beam of just over 41 feet, and will be powered by Rolls Royce Olympus and Tyne gas turbines. She will have a Seacat anti-aircraft missile system, a 4·5 in. Mk. 8 gun, and a Wasp helicopter which will later be replaced by a twin-engined Lynx.

As in other ships of the class, her living accommodation will be of a high standard, with bunk sleeping, separate dining halls and cafeteria messing. She will have air-conditioning.

H.M.S. *Alacrity* is the ninth ship of the Navy to bear the name, the first being a sloop of 18 guns built at Newcastle in 1806, and the last also a sloop, launched in 1944, which saw active service during the Korean war, and was scrapped in 1956.

DEVICES AND MATERIALS FOR FAULT-FINDING TRAINING AND TRAINING RESEARCH

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Introduction The training of electronics maintenance technicians has been the object of study in a large number of research projects during the past 25 years. Much of this effort has been devoted to the development of training courses, training devices and aids which, in many instances, have been designed to meet the training requirements of specific equipments. It is perhaps fair to say that there has been rather less work done in developing devices with generalisable properties, designed to provide facilities for representing the task requirements of fault-finding on a range of equipments. The devices described here attempt to provide a generalisable maintenance training facility both for practical training purposes and as a media for research to define and measure potentially important training variables.

A complementary approach in recent years has been to explore ways of presenting technical data in a form which makes the fault-finder's task simpler. Thus, one approach has been to produce maintenance manuals which specify optimal check-out routines for the fault-finder to follow. An alternative approach has been to produce functionally oriented manuals of which the FIMS handbooks are an example. The latter contain circuit diagrams which have been specially prepared to clearly show signal flow, functional dependencies and which also show many more test points than are found in conventional diagrams. In addition, full data is given on the correct reading which should be obtained at each test point along with instructions on suitable oscilloscope settings. A number of FIMS manuals have been produced by the Navy but in many cases traditional handbooks are used for fault-finding. In each case the primary aim of Naval training courses is to provide the trainee with a thorough knowledge of the functional operation of the equipment being taught. Whichever type of functional manual is used it is apparent that the technician, when fault-finding, has many decisions to make, especially in interpreting symptoms, deciding at which test-points to check and in then deciding whether or not the test reading deviates from that which is normal. The nature of these decisions (or with what these decisions should ideally be) is the ultimate concern of our future research.

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The Fault-Finding Procedure

The value of the devices described here will depend to a very great extent on the accuracy with which they simulate the requirements of the real maintenance task. For this reason, some preliminary discussion of fault-finding procedures is perhaps necessary as this, in effect, entails a definition of the fault-finding ' philosophy ' underlying the devices.

Electronic equipments vary greatly in their function, complexity and in the type of circuitry they use. Notwithstanding, there appears to be a core of consent among experts as to the main constituents of the fault-finder's task *e.g.* McKnight and Butler (1964), Rigney (1965). In essence, the fault-finder is involved in a search; a process by which he eliminates suspect parts of the equipment and progressively narrows the area of inspection until he can identify the faulty unit, circuit-board or component. Within this framework of search there are innumerable variations depending on the strategy adopted by the individual and his knowledge of the equipment. A number of research studies have shown that experienced fault-finders differ widely in their methods and that, in many instances, these are inefficient and unsuccessful *e.g.* Dale (1958), Highland *et al.* (1956). It is apparent from these sources and from many others that the primary reason for poor fault-finding performance is the failure to use a logical approach coupled with an inability to interpret symptoms.

(a) *Symptom Analysis*

The first stage in logical fault-finding is to identify and interpret the symptoms which indicate that a fault is present. Very often the symptoms will be visible on a display and the maintainer must identify which display parameters are absent, distorted or weak. From his functional knowledge of the equipment, he should then be able to hypothesise on the particular units or modules which could, if faulty, produce the symptoms observed. At the same time, he should ideally identify those equipment functions which are still operational; if necessary this might require a systematic check-out of all the equipment controls to see their effects on the display.

There is evidence that symptom analysis is often perfunctory and that difficulties are commonly experienced in interpreting the functional implications of symptoms. Rigney (1965), when discussing the results of a maintenance performance test, commented that " the worst problem is the inability to perform symptom recognition adequately ".

(b) *Isolating the Faulty Unit: Logical Checkout*

The technician must next take test measures. Ideally, he will be influenced by the information he has collected during symptom analysis so that his first checks might be taken to confirm or reject his predictions. The symptom, however, might be unfamiliar and thus meaningless or the equipment might be one he has not dealt with frequently. In such cases it may be necessary to perform a comprehensive check-out of the entire equipment. Working from circuit diagrams, the maintainer might thus first decide to take readings at test-points at the final output stage of each main signal path. Using an optimal strategy, he would then consult his diagrams and take readings at those test-points with the highest information value. He might thus check at test-points between the major units until he has defined which of these contains the fault. He would then continue to check within the suspect unit, attempting with each check to halve the area in which he can be certain the fault lies. The optimal check-out procedure would thus be that which uses the fewest checks.

Much remains to be understood about the skills required and the type of training which may be necessary to produce optimal check-out performance, notably in the skills required for reading circuit diagrams and tracing signal flow.

(c) *Waveform Interpretation*

The oscilloscope is the main test instrument used during check-out at the level of the equipment unit. The maintainer must understand the principles by which to select appropriate oscilloscope settings and must then be able to interpret the waveform (*i.e.* to judge whether or not it is correct). In conventional handbooks, important waveforms are drawn on the circuit diagram, but, where these are not given, the maintainer will have to predict what the waveform should be from his knowledge of circuit functioning. As noted above, all waveforms are illustrated in FIMS handbooks so that the task is a straightforward comparison.

(d) *Fault-Finding at Component Level*

This stage is often redundant as modern equipments frequently utilise replaceable cir-

cuit-boards. Where it is necessary, the task may be made easier by first checking the circuitry for signs of damage such as burned or discoloured components or broken wires. In the absence of these, the maintainer must generally take voltage and resistance readings or check valves. The selection of a suitable measure (*e.g.* whether to measure voltage across a component or to earth) and its interpretation depends largely on such factors as whether components are in series or parallel, so that proficiency requires a knowledge of Ohm's Law and its derivatives. However, much of the activity at this stage is rather aptly referred to by maintainers as 'groping', which implies a rather haphazard search which may of course be frequently successful.

The Devices

The devices are listed in Table 1. For demonstration and research purposes, the devices have been designed to simulate the task requirements of a particular equipment (the JDA radar display), but it may be emphasised that they are felt to be sufficiently flexible (or sufficiently simple and cheap) to permit them to be adapted for teaching fault-finding techniques on most electronic equipments.

Devices for Symptom Analysis

(a) *The Bolex Projector* (Fig. 1)

It was felt important that symptom material be as similar as possible to that seen on the equipment. For this reason, and because radar and sonar displays present moving data, the decision was made to use colour films of symptoms for training purposes. The Bolex projector was chosen because it uses film-cassettes and is very simple to load and operate. Each cassette holds 50ft. of film allowing the trainee a maximum viewing time of three minutes at normal projection speed. The projector has an automatic re-wind and eject facility operated by a press-button and the film can be re-wound at any stage of projection. The trainee should thus have ample time to study the symptom and the simplicity of the projector makes it easy for trainees to load and operate it without instructor supervision.

This facility can also be used to show trainees the appearance of the normal working display and to show the effects on the display of adjustments to the operator controls. If a sufficient number of faults have been filmed the trainee, after instruction, can practice

TABLE 1.
Devices for fault-finding training and research

Task aspects	*Devices*	*Costs*
1. Symptom analysis	(a) Bolex Projector with 8 mm. film cassettes	£45 £2 per film
	(b) PIP Projector	
2. Isolation of faulty equipment units (logical check-out)	(a) Flow-Diagram Trainer (FDT)	£1100
	(b) Block-Level Location Trainer (BLLT)	£600
3. Waveform Interpretation	(a) Carousel Slide Projector (random-access model)	£220 40p per slide
	(b) Automated Microform Terminal (AMT)	£6000
4. Component Isolation	(a) Component-Level Location Trainer	£800

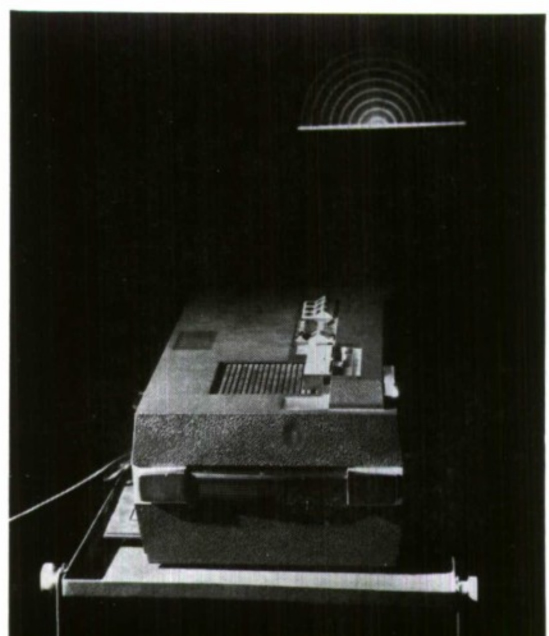

FIG. 1. The Bolex Projector.

symptom interpretation on filmed examples. In the case of the JDA, over 40 separate faults are available on film.

(b) *The PIP Projector (Phillips Programmed Individual Presentation Projector)*

This sophisticated cassette projector offers additional features. It takes two cassettes, one of which holds film whilst the other holds magnetic tape for audio presentation. The PIP can provide a synchronised audio-visual presentation if this is desired and, in addition, frames can be projected individually as stills. The frame-advance facility is controlled by pulses which can be placed on the magnetic tape.

The PIP provides a means to give realistic feedback to the trainee on whether or not he has correctly identified a fault at the conclusion of his search. At the end of a real check-out on an equipment, the maintainer would replace a component or unit and would then monitor the display to see if it has returned to normal. If the fault remains he must continue fault-finding. This requirement can be simulated by dividing the PIP film into two lengths with the first showing the symptom and the second showing the normal display. When the trainee decides that he has found the unit containing the fault, he punches in its identity on the Identifier Keyboard (see p.270). If his choice is correct a code is sent to the PIP projector which then displays the normal picture. If his choice is other than the correct one, the projector can be made to automatically re-wind and to then re-show the film of the original symptom.

Devices for Logical Check-out (Isolation of the Faulty Equipment Unit)

(a) *The Flow Diagram Trainer* (FDT) (Fig. 2)

The Flow Diagram Trainer is based on the simple idea of having trainees perform check-out on a block flow-diagram of the equipment rather than on the equipment itself. This makes the task of check-out less demanding as the trainee is not required to study location diagrams and does not have to search in the equipment for test-points. He does not need to set up an oscilloscope to obtain test readings as these are provided automatically when he touches any test-point with a probe. The trainee can thus carry out a complete check-out in far less time than if he were to practice on a real equipment and he should have the opportunity to practice check-out on more faults than might be otherwise possible in what is generally limited training time. It is likely that such concentrated practice will lead to an increased understanding of the diagram on which he is working.

The FDT consists of a formica panel on to the surface of which is bonded a block flow-diagram of an equipment. As can be seen in Fig. 2, the diagram for the JDA radar display shows all the main units and sub-units (such as amplifiers, multivibrators, etc.) along with all signal paths. Colours are used to differentiate the main functions so that, in the case of the JDA, the Scan Deflection units and signal paths are drawn in blue whilst the Scan Modulation units are yellow and the signal paths are brown. The drawing follows FIMS principles in that signal paths are laid out so as to make flow tracing easy and all test-points are included.

A means is provided for changing the panel and it is thus possible to use the FDT to teach any equipment. To do this, the panel is laid on top of a second permanent panel whose surface has been drilled with a matrix of $\frac{3}{4}$in. holes. The test-point holes in the diagram-board are drilled on the same matrix so that, when the boards are laid on top of each other, the holes coincide. The appropriate light-guides (the tip of which constitutes the test-point) are then pushed up through the two holes to the surface of the board.

Simplified Test-point Data

When the trainee places a probe against a selected test-point a green or a red light comes on in its centre. The red light indicates to the trainee that the reading at the test-point is abnormal whilst the green light indicates that the reading is correct. A red light will appear at test-points on signal-paths leaving the faulty unit but the light will be green at test-points on

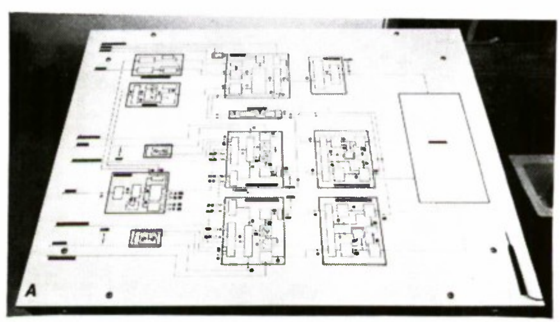

FIG. 2. The Flow Diagram Trainer.

signal-paths leading to the faulty unit or on signal-paths unaffected by the fault in other parts of the equipment.

If a new fault is given to the trainee it will then be necessary to change the colour of the light at certain test-points and for practical purposes this needs to be done quickly. To do this, one must change the colour of the light entering the light-guide, the tip of which is visible to the trainee at the test-point. The light for each light-guide is provided by a light-bulb which is switched on when the trainee touches the test-point with the probe. Between the receiving end of the light-guide and the bulb is a transparent filter mounted on a solenoid. The top half of the filter is red and the bottom half is green; the green part of the filter is opposite the light-guide when the solenoid is open. When the solenoid is closed, the red part of the filter is pulled down opposite the light-guide. A programme card is inserted into the device to close the solenoids for those test-points where the light must be changed. A separate programme card must thus be prepared for each fault.

The simplified test-point data is provided to allow the trainee to concentrate on the logical aspects of check-out. When the trainee's logic meets the required training standard he will then be required to perform his check-out with waveform data.

(b) *Waveform Interpretation*
(i)*The Carousel Slide Projector* (Fig. 3)

Photographs were taken of waveforms on an oscilloscope which was connected, in turn, to each test-point in the JDA radar display. These were then made into slides for presentation by the Carousel slide projector (random-access model). When a test-point is touched with the probe, a binary code is sent to the Carousel projector which then automatically hunts the appropriate slide and projects it on a screen. The trainee must then compare the picture with that given in a waveform handbook.

The storage capacity of the slide holder is limited, however, to a maximum of 80 slides so that this device might not be suitable for large equipments with more than 80 test-points. However, the storage capacity is probably adequate for smaller equipments and if the equipment is large, it might be possible to limit the number of test-points by including only those which are important. Where this is not possible (as in a complex multi-equipment system) a projector with a much larger storage would be needed. This is provided by the Marconi Automated Microform Terminal.

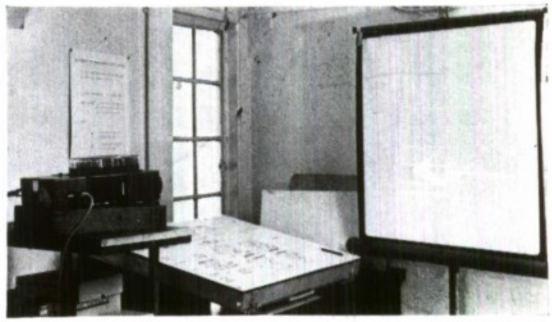

FIG. 3. The Carousel Slide Projector.

(ii) *The Automated Microform Terminal* (AMT) (Fig. 4)

This state-of-the-art projector provides a very fast random-access and display facility. Graphics or alpha-numerics are stored on 6 in. × 4in. ultrafiche each of which can hold up to 6000 individual frames depending on their size. It would be possible, in the case of the JDA, to store complete waveform data for over 50 faults on one fiche. The random-access facility makes it possible to display any one of up to 6000 frames in under $1\frac{1}{2}$ seconds. As with the Carousel projector, individual frames are accessed (*via* coding interfaces) by touching test-points on the FDT with the probe.

This device is expensive, although a cheaper version is under commercial development. To be cost effective, the AMT might perform several functions. It could be used, for example, to store voltage and resistance readings where it is necessary to train fault-finding down to component level. It could store handbook material, teaching material and instructions and examination material as its capacity is equivalent to that of a small computer (especially in the storage of graphics).

(c) *The Block Level Location Trainer* (BLLT) (Fig. 5)

A possible limitation of the Flow Diagram Trainer is its lack of physical resemblance to the equipment which it is being used to teach. Because of this, it may have a lower acceptability to trainees than a device with the same purpose but which also resembles the equipment in appearance. Again, the FDT is designed so that trainees do not have to locate

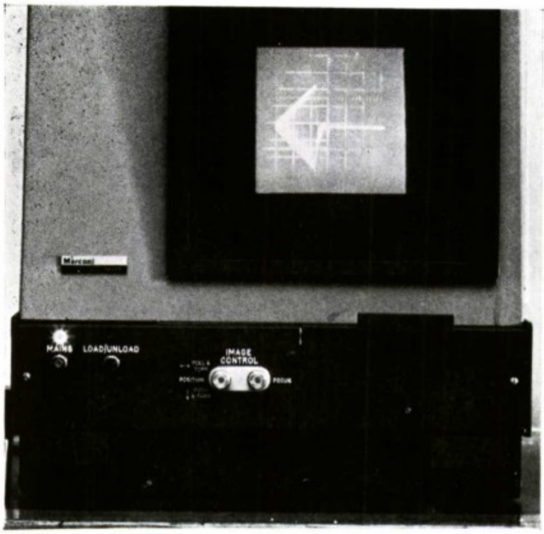

FIG. 4. The Automated Microform Terminal.

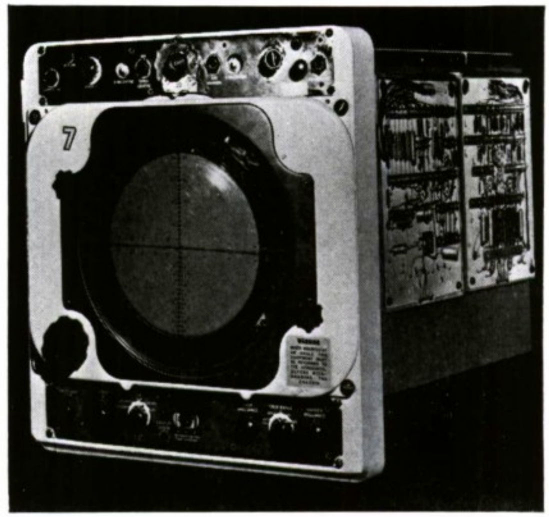

FIG. 5. The Block Level Location Trainer.

test-points on the equipment but it may be necessary to give practice at this. The BLLT was designed to meet these possible limitations.

Basically, the BLLT is a photographic model of an equipment (in this case the JDA radar display). Each tray of components (*i.e.* each equipment unit) was photographed, along with the display and front controls and these were then mounted in metal trays which were screwed to a frame to provide a full-scale mock-up of the set. Tag-strip pins were simulated by small metal pins driven into the tag-strips on the photographs (there are over 500 such pins on the mock-up). Where a particular pin functions as a test-point, a wire was attached to the underside of the pin and this was taken to a diode-board which provides the test-point code to the Automated Microform Terminal. Thus, when the test-point is located and touched with a probe, the appropriate waveform photograph will be displayed on the AMT.

Fault-Finding at Component Level: The Component Level Location Trainer

This device is at the design stage: it is essentially an extension of the BLLT in that it would be based on a photographic equipment mock-up. Each and every component on the photograph would be provided with a test-point so that all tag-strip pins would be wired. As with the BLLT, touching a test-point with the probe would access data stored in the Automated Microform Terminal, in this case voltage or resistance readings.

Student Response Recording Facilities

A complete punched paper-tape record of trainee activities will be taken. A sequential log will be kept of all test-points probed during check-out on both the Flow-Diagram Trainer and the Block Level Location Trainer. In addition, the trainee has an Identifier Keyboard on which to record his diagnosis. This consists of an array of keys each labelled with the name of a main equipment unit (such as 'Calibrator') and a set of keys numbered one to nine, These are used by the trainee to indicate where he has decided the fault lies; for example, he might punch in 'Timing Unit' and '4', indicating his belief that the fault lies in sub-unit 4 of the Timing Unit.

Future Research

There are a number of ways in which the devices could be improved and developed but, in the immediate future, work will concentrate on experiments in which the devices will function as research tools.

Performance Testing and Measurement

The devices can be used as performance tests to define and measure those aspects of the maintainer's task which give difficulty and in which mistakes are common or methods inefficient. The most valuable data here may be gathered by studying the performance of relatively inexperienced fault-finders who are new to the equipment and by measuring rate of improvement as a function of training and

practice. Such data could then indicate task aspects on which training effort needs to concentrate and which it might be profitable to study further in an experimental setting.

Systematic Study of Training Variables

A review of previous research suggests that much effort has gone into the design of maintenance training courses based on procedures and materials which are felt rather than known to improve the learning of fault-finding. Very few studies have been concerned to define and systematically *vary* training conditions in an experimental setting so that there is little evidence on the *comparative* merits of possibly important training variables. Such variables as amount of practice and the type and amount of factual material needed by the maintainer are of obvious interest, as are such factors as the order in which materials are presented and practised and how best to measure and evaluate ongoing performance for feedback to the trainee. There is a need to define the conditions which may improve the long-term retention of facts, procedures and principles (the optimal conditions for each may differ) and there is an equally important need to identify the type of course content and practice conditions which may facilitate performance on other types of equipment. It is hoped that it may be possible to use the devices to provide tasks for studying the effects of systematic changes in training conditions upon performance. Statistical procedures such as Response Surface Methodology (Box and Wilson, 1951), which permit the design of experiments involving simultaneous variation of a large number of variables, will be particularly useful for these purposes.

General Training Methodology

Studies such as the above should also provide more general data on the design of equipment-based training courses. The interest here is in the mechanisms of training rather than in specific subject-matter. Attention here will focus particularly on the needs of the individual trainee. There are wide trainee differences in specific abilities, speed of learning, preferred manner of study and in the amount and type of previous relevant experience and knowledge brought to the training situation. The intention is to explore ways of identifying and measuring learning differences between individuals and to define the type of factual material and practice appropriate to the abilities and experience of the individual trainee.

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STATISTICS OF RELIABILITY ASSESSMENT

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Introduction The subject of this article is "The Statistics of Reliability Assessment". Why do we need statistics? It is because Staff Requirements now call for Reliability in quantitative terms. But Reliability is a probability, *i.e.* the probability of success for a specific period of time, under specified conditions of use. Safety is also a probability problem and is concerned with that function of reliability where failure can result in a hazardous situation. The problems of reliability assessment therefore are concerned with probability theory, which is a branch of statistics.

Historical Background

Because statistics is a mathematical subject reliability assessment techniques have in the past been left to the mathematician. As a result assessing reliability has been treated as a numbers game, and became divorced from the engineering aspects of reliability. Engineers have been presented with the "Cook-book" approach which has led to disenchantment with statistics. In consequence no real effort has been made to assess whether or not the reliability requirements have been met with any measurable degree of confidence.

Object of the Presentation

The object of this presentation is therefore to reconcile statistics with engineering judgement and to present the subject in a graphical manner, avoiding mathematical formulae as far as possible.

The Basic Rules of Probability

There are two basic rules of probability, the addition and product rules. The addition rule applies to an *or* situation, *e.g.* the probability of throwing a one or a two with a six sided dice is $\frac{1}{6} + \frac{1}{6} = \frac{1}{3}$.

The product rule applies to an *and* situation, *e.g,* the probability of throwing two sixes with two six sided dice is $\frac{1}{6} \times \frac{1}{6} = \frac{1}{36}$

With reliability assessment therefore it is necessary to produce a reliability logic diagram determining the *and* and *or* functions.

In general for a series system the system reliability is the product of the part reliabilities as the system will only work if all parts are successful.

For a parallel or redundant system the unreliability of the system is the product of the unreliabilities of the parts as the system only fails if all parts fail.

For a reliability model therefore the logic diagram is essential for determining which of the two basic rules of probability is appropriate.

Samples and Distributions

If we had complete knowledge about a population we would know how many items would fail and how many would be successful. In this case of course we would avoid using the defective items or repair them and thereby achieve 100 per cent reliability. Unfortunately life is not so simple and we have to make estimates on the basis of samples taken from the popula-

JOURNAL OF THE

ROYAL NAVAL SCIENTIFIC SERVICE

VOLUME 29

1974

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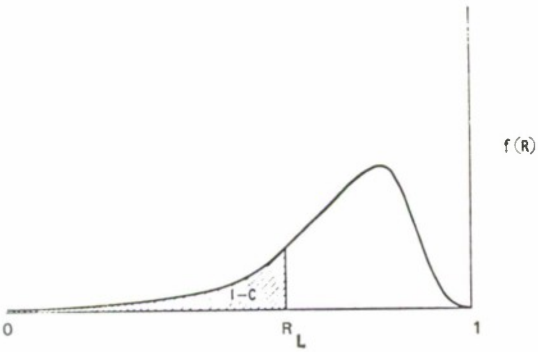

FIG. 1a. Distribution of R.

tion. Our knowledge of the reliability is therefore not a unique value but a distribution (see Fig. 1a).

The distribution shown f(R) is typical for reliability, *i.e.* skewed with a single mode, which occurs at the most likely value.

Now the relative area under the curve gives the probability that the value of R lies below a certain limit R_L. By drawing a curve of the relative areas under the curve we can produce a cumulative curve F(R) (Fig. 1b). One minus F(R) gives us the confidence that the value of R is at least R_L. Hence R_L is a confidence limit and $1-F(R)$ is the confidence level C.

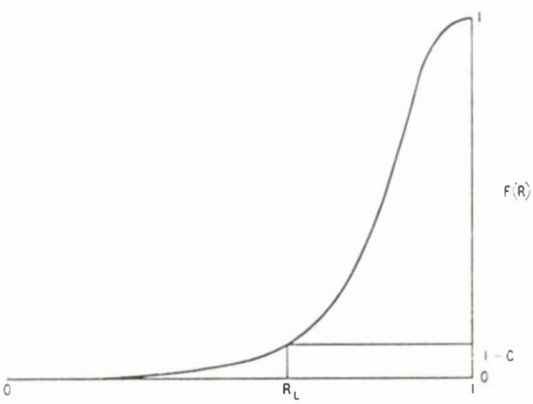

FIG 1b. Cumulative distribution of R.

Classical Methods

With classical methods we do not in fact know the distribution of R but make inferences from test data alone and ignore prior knowledge or engineering judgement. Such inferences can be very misleading. For example suppose I am holding a pencil and let it go and it drops to the ground. On the basis of this one trial a classical statement on the probability of repeating this trial would be "There is at least a 5 per cent probability that the pencil will drop if let go, with 95 per cent confidence", *i.e.* we are 95 per cent confident that at least five pencils in 100 will drop if let go! In practice of course as we know something about the laws of gravity we are certain that if we let go of a pencil it will drop. This is prior knowledge which we should use.

As a second example let us take an item which has to have a very high reliability. Using engineering prediction techniques we can show that the reliability is about 99·98 per cent, *i.e.* we do not expect more than roughly two failures in 10,000. However, if we only have 10 to test the classical method will merely say that the reliability lies somewhere between 69 and 100 per cent which under the circumstances is not very helpful!

Whilst the classical approach allows simple tables to be used, this "Cook-Book" approach is practically useless for high reliability when using small samples. The solution to the problem lies with the use of Bayesian statistics.

Bayes Theorem

Bayes Theorem dates back to Dr. Bayes who died in 1761 and whose theorem was first published in 1763. It is in fact a simple derivation of the product rule of probabilities. You will find Bayes Theorem presented in a variety of forms. In this case we will use it as it applies to reliability assessment.

Let us assume that by using engineering judgement or prediction techniques we have some prior distribution of R. We can denote this prior distribution as

$f(R|E)$ *i.e.* the function of R given some engineering knowledge E.

If we get some subsequent test data D we want to know the new function of R having obtained this data in addition to our prior knowledge E. This new or posterior function is given by

$$f(R|DE).$$

Now we can also determine the likelihood of getting a particular test result D if the reliability is R using for example the binominal distribution and denote this by

$$f(D|R).$$

Bayes theorem then gives us

$$f(R|DE) \propto f(D|R) \times f(R|E).$$

If we draw these three distributions on the same graph it will be seen that the posterior distribution corresponds to the area where the prior and likelihood distribution overlap. In

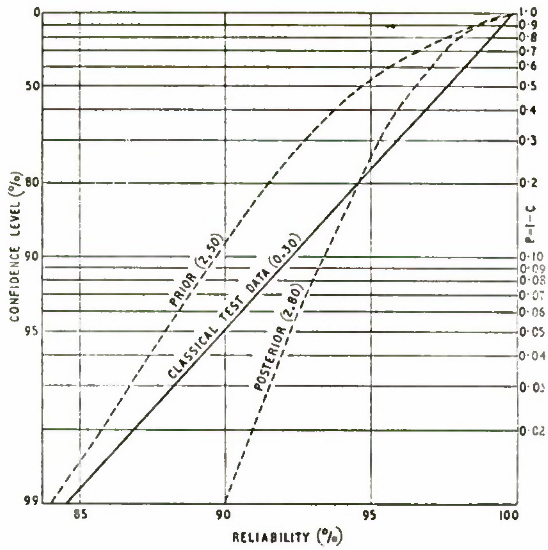

FIG. 2. Cumulative distributions.

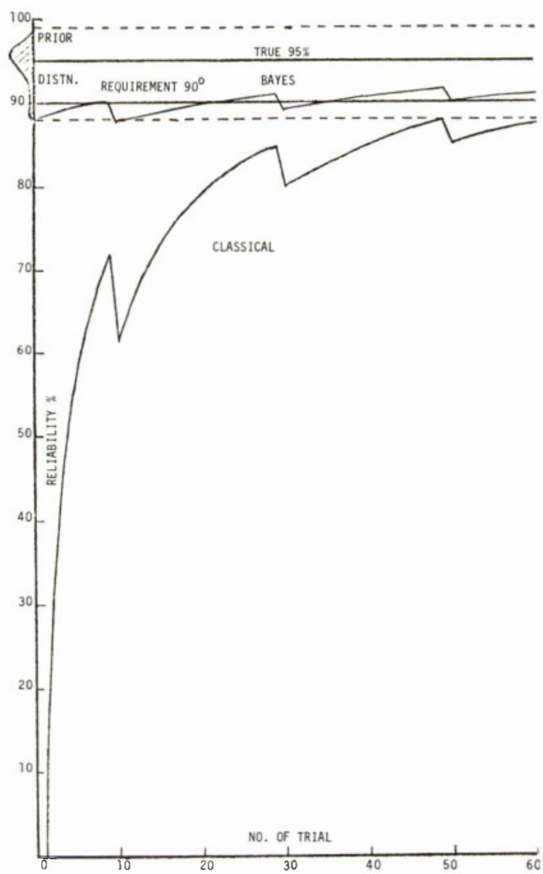

FIG. 3. Plot using Bayesian Methods.

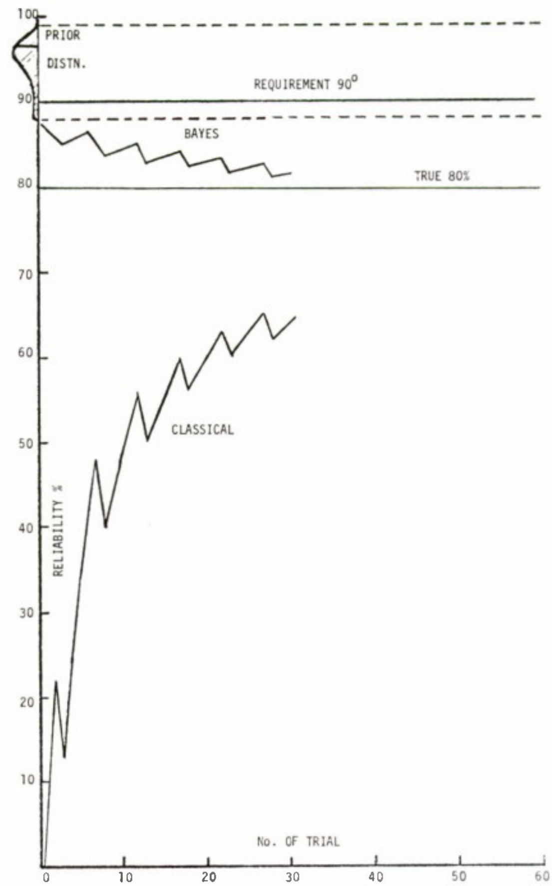

FIG. 4. Plot using Bayesian Methods.

other words Bayes Theorem updates prior knowledge with subsequent test data to produce a revised distribution. The classical approach is to assume no prior knowledge and that all values are equally likely, *i.e.* $f(R|E)=1$ for all values of R, which results in

$$f(R|D.E) \propto f(D|R)$$

and classical confidence levels are obtained directly from the likelihood function.

Reliability and Confidence Level

As we have already shown in Figs. 1(a) and (b) confidence level is obtained from the cumulative function F(R). As both reliability and confidence are probabilities they often get confused. The reliability is the probability of success of a future event whereas confidence is a measure of belief based on past evidence. As we are usually concerned with obtaining a reasonably high level of confidence it is more convenient to draw cumulative curves on a

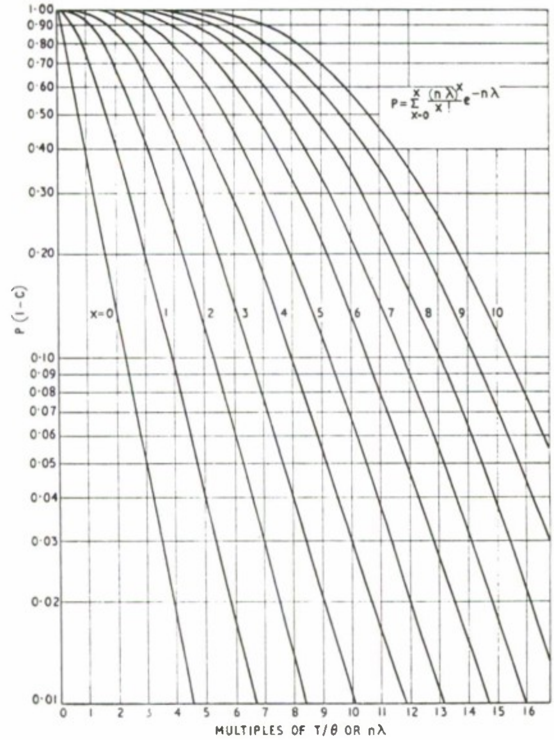

FIG. 5. Poisson OC curves.

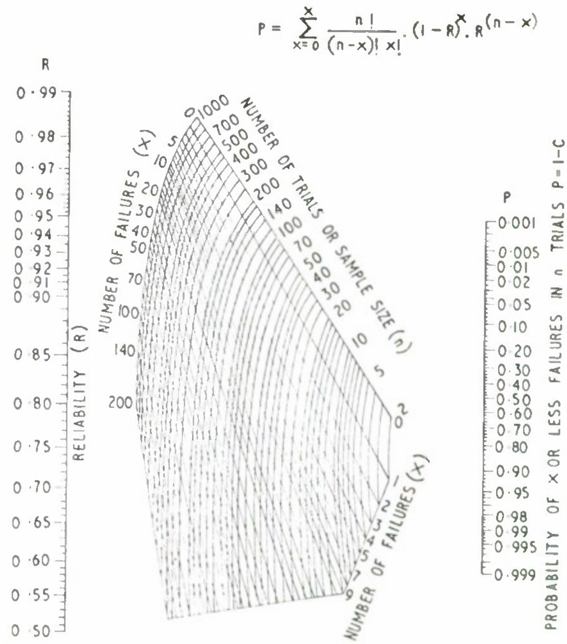

FIG. 6. Nomograph of the cumulative binomial distribution.

log-linear scale (see Fig. 2), as this has the advantage of centralising the 90 per cent confidence level and making the curves straighter and easier to read.

Classical Vs Bayesian Assessments

If we plot the assessed reliability progressively as trials proceed using the classical and Bayesian methods the plots will be roughly as shown in Figs. 3 and 4. Fig. 3 shows a situation where the true reliability is in excess of that required and Fig. 4 shows a case where the achieved reliability falls below the requirement. The curves basically speak for themselves in showing the advantages of the Bayesian approach in both cases.

Predictions

With Bayes Theorem the prior distribution is of great importance. Bayesian statistics therefore depends for its success to a great extent on the ability of engineers to use their engineering knowledge and come up with some predictions. Prediction techniques need to be improved but a considerable amount of work is going on in this field, for example the recent publication of the G.W. Reliability Prediction Manual. These techniques have been used extensively in the N.A.S.A. programmes.

The Differences

We can sum up the fundamental differences between Classical and Bayesian methods by saying that the classical approach is to test before you think, whereas the Bayesian is to think before you test.

*Note. Figs. 5 and 6 provide curves for use with the Poisson and binomial distributions and may be used as cumulative gamma or beta functions. If prior data is available the curves may be used as posterior functions by substituting b+x and a+n, for x and n when b is the prior number of failures and a the prior sample size.

PROOF AND EXPERIMENTAL ESTABLISHMENT ARMY DEPARTMENT INCHTERF

Commander W. Y. McLanachan, R.N., Rtd.

FIG. 1. The " Lochinvar " Room used as the Main Conference Room and as an Officers' Mess Annex. Photo shows the Ship's Crest presented by H.M.S. *Lochinvar*.

Introduction and History

P & EE Inchterf, is a Closed Range, situated near Kirkintilloch 12 miles north-east of Glasgow. Originally used by Messrs. Beardmore & Sons Ltd., it was taken over by the Government in the late '30s and the first round was fired in July 1940. The site is a sandy one in an area of marshy ground, the country in the immediate vicinity being industrial and until recently mainly coal mining. It is also a semi-urban area. A relatively small area has been fully developed for current needs. The Establishment takes its name " Inchterf " from the original farm of Inchterf whose buildings, byre, dairy and barns are in the magazine area and are used for storing projectiles. The name Inchterf means island in the bog and in the circumstances is very appropriate. From its opening in 1940 until 1958 the Superintendent at Inchterf was either an RN or RM Officer from the Chief Inspector of Naval Ordnance's (now DN Ord S) department. From 1958 - 1969 the Superintendent's post alternated Army and Navy but since 1969 the post has become an Army one. This is reasonable, as the percentage of Naval Proof and Trials has decreased in parallel with the decrease in guns carried in H.M. Ships. However a good liaison is still maintained with the R.N. and the Main Conference room, reconstructed in 1972 is known as the " Lochinvar " Room after H.M.S. *Lochinvar*, the naval minesweeping establishment (see Fig. 1).

Task

(a) *Propellant Proof*

(1) Propellant is manufactured in Lots. In order to obtain constant performance from Service propellants, samples are taken from each Lot, and matched against a Standard Lot, the charge weight of a Lot in any gun being determined by its ballistic performance compared to the Standard.

(2) The selection of a suitable Lot for adoption as a Standard for each equipment/propellant combination, both Naval and Land Service, is initiated at Inchterf. The subsequent work of making up, storing and checking of ballistic performance, of all such standards, is one of the Establishment's primary tasks.

(3) With the increase of NATO projects and sales abroad the efficient maintenance of Standards is of paramount importance.

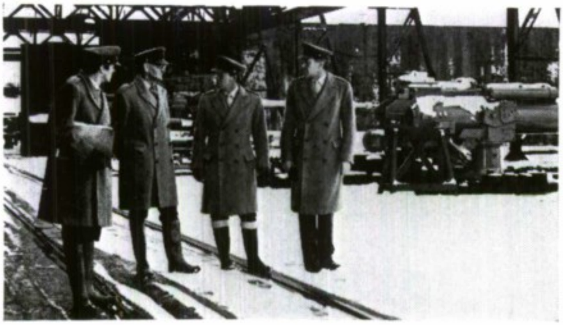

FIG. 2. *West* Battery showing general layout of cranes and proof stands. Naval 4·5 Mk. 8 gun is shown in the background.

(b) *Functional Proof (Land and Naval Service)*

(1) Includes complete Ordnance and Ordnance components, *i.e.* barrels, breech rings, breech blocks, buffer lugs, etc., are proved by firing before issue to the Services.

(2) Also ammunition components, *i.e.* primers, tubes, cartridge cases, proof shot etc., which are manufactured in Lots and a sample from each lot is proved by firing, before being put into service use.

(c) *Trials*

These form an ever growing proportion of the firings at Inchterf. Trials cover such subjects as:

(1) Determination of charge weights of new propellants to match the performance of new and existing charge designs.
(2) Ignition efficiency.
(3) Investigation of wear and its effect on muzzle velocity and chamber pressures.
(4) Methods of Pressure Measurements.
(5) Performance of propellants at various temperatures (" Temperature Correction Firings ").
(6) Determination of Ballistic Co-efficient of Projectiles.
(7) Flash, smoke and debris observations.

Capacity and Limitations

(a) The current rate of firing is approximately 15,000 rounds per year. Basic facilities exist to undertake up to three times this rate of firing, given appropriate staff. Capacity, however, cannot be fully expressed in terms of rounds fired. Ballistic firings and trials may involve considerable preparation, analysis and reporting work, compared with proof of ordnance and ammunition components.

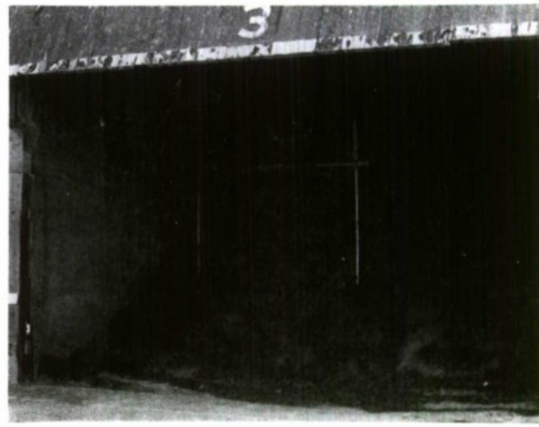

FIG. 3. The Sand Bay with steel tunnel to protect sides of bay from shot break-up.

(b) The current proportions of firings in terms of rounds fired is as follows:

Proof of Ordnance and Components	50%
Proof of Propellant	20%
Trial and Standardisation Firings	30%

FIG. 4. Stick propellant being cut to suitable length for make-up of charges.

FIG. 5. Making and marking charge bags in the Tailor's Shop.

(c) *Other Limitations*

(1) Calibre:
Guns equivalent to 7·2 in Howitzer or 180 mm. are considered to be the heaviest which can be fired without serious risk of damage to nearby civilian property. The stop-butt capacity is known to be 12 in Howitzer (fired in War 1939 - 45).

(2) Projectiles:
Closed Range conditions demand freedom from break-up of projectiles in flight.

(3) Type of firings:
Complexity and varieties of design of charges to be made up may increase time and cost of trial.

(4) Weather:
Firing cannot take place unless the stop-butts are visible from the firing point. Complaints from local inhabitants of excessive noise, vibration etc. may occur if high velocity guns are fired when the weather index is high.

Noise

(a) Noise is a sound which is undesired by the recipient. At Inchterf every endeavour is made to ensure that the minimum amount of sound reaches the recipient. This is achieved by positioning the noisier weapons where they produce the least noise and by taking account of the weather conditions.

(b) All range staff are also made fully aware of the dangerous effects of noise on the ears, and adequate supplies of Amplivox Ear Defenders and Billesholm Swedish down are available. An audiometric unit visits the range twice annually and records are maintained for all the staff tested.

(c) A noise monitoring system, consisting of four outstations in the most sensitive positions in the surrounding area, was installed in August 1971. The system has facilities for further outstations should they be needed. The noise monitoring system records impulse noise continuously, and hence if and when complaints of gun noise are received, the noise level at the time of complaint can be checked.

(d) A continuous record of wind speed and direction is automatically recorded in the control room, the anemometer and wind vane being mounted on a 50ft. wind tower positioned in the N.E. corner of the range. From these readings the Instrumentation Officer compiles a local weather index. Glasgow Weather Centre also gives a Weather Index daily to the Range.

FIG. 6. 120 mm. L11 bag charges being made up Note the lead foil used as a de-coppering agent

FIG. 7. Sewing charge bags for make-up of 105 mm. SP charges.

Staff

(a)

(1) Superintendent	1	Army (Lt.-Col.) GSO 1 (W)
(2) Technical Officer	3	1 Army (Major) GSO 2 (W) 1 RN (CINO Grade C Post) 1 RA (TRO 3)
(3) Warrant Officers	3	1 WO 1, 2 WO 2 All AIG RA (on AIG Field Roll for promotion purposes).

(b) *Civilian Non-Industrial*

(1) Executive Officers	1	(1 HEO, 1 EO)
(2) Scientific Officers	3	(1 SSO, 2 HSO)
(3) Technical Grades	2	(PTO 4)

(4) Process and General Supervisory Grades 8
(5) COs and CAs 5 (3 COs, 2 CAs)
(6) GOAs 3
(7) Typists 2
(8) Telephonist 1

(c) *Civilian Industrial*
(1) Skilled 17
(2) Unskilled 117
(3) Fire/Patrolmen 14

(d) *Attached*
(1) D. of E. Site Maintenance, Boilerhouse, etc. 19
(2) QAD (W) Gun Examiners 6 (includes 1 PTO 4)
(3) Railway Gp RCT Driver, Shunter 2
(4) Canteen Services Supervisor, Staff 2

FIG. 8. Main Issue Room showing 105 mm. L7 and 105 mm. SP charges at final preparation ready for issue to conditioning chamber.

FIG. 9. Reading off pressure from compressed copper crusher gauge.

Range Facilities

Batteries

(a) *EAST Battery*
8 Gun positions (1 for field carriages)
5 Sand Bays (4 with steel tunnels for the firing of pointed projectiles, or of shot liable to break-up in the bay).

(b) *WEST Battery*
8 Gun Positions (2 for field carriages) (See Fig. 2).
6 Sand Bays (each with steel tunnels) (See Fig. 3).

Notes
(1) Both Batteries: Range, Firing Point to sand bays is 150 m.
(2) *WEST* Battery: A firing point for RCL guns with the necessary protection against back blast and used for firings of the 120 mm. RCL equipments, is set up on the West side of the Battery; it is also used for firing mortars.

(c) *Third Battery*

A single firing position with one sand bay and tunnel, range 70 m. This battery is used mainly for 76 mm. firings.

Magazine Section

(a) In addition to making up, packaging and storing propellant standards, this Section assembles all ammunition including the propellant charges required for Proof and Trials. See Figs. 4 - 10 inclusive.

(b) Facilities include.
(1) *Storage Magazines:*
Propellant (Cat. Y) Five Magazines
Total Approved Capacity 200,000 Kgs. (440,000 lbs.) Cat. Y.
Total Actual Capacity 150,000 Kgs. (330,000 lbs.) Approx. Cat. Y.
Powder (Cat. ZZ). Two Magazines.
Total Approved Capacity 6,500 lbs. Cat. ZZ 3,000 Kgs.
Total Actual Capacity Cat. ZZ 6.500 lbs.

Notes
(1) Physical capacity may be affected by packaging. (Propellant Standards are stored in Canisters.)
(2) The Canister mostly used for storing Standard Propellant charges is the aluminium Alloy Case Magazine RN Mark 1 (N) formerly used for storing Naval 6 in. Gun Propellant.

3. Propellant Magazines are fitted with heating, but without means of cooling below ambient temperature. Normal temperature range is 13°C to 18°C.

(c) *Machines:* Indenting; for cartridges from 76 mm. to 120 mm. RCL (BAT) Bullet Pull Test, up to 8,000 lbs. pull (up to 105 mm. cal.).

(d) *Propellant Temperature Conditioning:*

(1) *East Battery:* Four Chambers. Range—Ambient to 32°C (Control ± 1°C). Maximum heating temperature normally restricted to 60°C.

(2) *West Battery:* Two Chambers. Range—Ambient to 32°C (Control ± 1°C).

(3) *Mobile:* One small trailer. Range—Range—Ambient to 60°C.

(4) *Refrigeration:* One Chamber. Range—Ambient to −40°C (Control ± 1°C).

(5) One of the chambers on *West* Battery has been used since 1969 on a long term storage trial for Chow Motors (Sea Dart). This trial will be completed by January 1976.

Instrumentation

The following can be readily measured and recorded:

(a) *Projectile Velocity*

Methods used:

P.C.C. (20 channels)

The equipment is used to record the velocity of a projectile at a particular point in flight. Muzzle Velocity and projectile retardation can be readily obtained.

(b) *Chamber Pressures:*

Methods used:

Copper Crusher Gauges (all types) (see Fig. 9), Strain Gauges, Strain Gauges (Patch) and Piezo-electric gauges.

Routine measurement of chamber pressure is carried out using Copper Crusher Gauges. For particular trails requiring dynamic pressure records, pressure time measurement is made using strain and piezo-electric gauges in conjunction with an Ampex Tape Recorder.

The 14 Channel FR 1900 Ampex Magnetic Tape Recorder in conjunction with an Ultra Violet recorder produces dry records of pressure and time (firing interval) to maximum pressure (Pmax). If time to shot ejection is required an induction coil device can be fitted. Pressure differences can be obtained using two gauges simultaneously in the chamber of a suitably prepared gun. See Fig. 10.

FIG. 10. Instrumentation Officer reading piezoelectric pressure and pressure difference from Ampex Tape Recorder.

(c) *Firing Intervals*

Methods used:

PCC

Ampex Tape Recorder (ATR)

PCC: Uses the "Extended Firing Interval" technique.

ATR: Produces photographic record showing the time lapse from firing the gun to Pmax, and shot arrival at the first skyscreen. Note: A Southern Instrument (4 channel Oscillograph) which produces wet photographic records of pressure and Firing Interval is kept as a reserve in case of failure of the ATR.

Miscellaneous

(a) *Fire Fighting and Physical Security*

Fire/Patrolmen are continuously on duty—Security Dogs are also employed.

(b) *Welfare*

(1) Medical—A civilian practitioner attends the staff. A trained Medical attendant is on duty during working hours to give First Aid treatment to Civilian and Military Staff.

(2) Canteen facilities—Full Canteen service is available.

(c) *Messes*

Officers and Warrant Officers messes exist within the Range. No facilities exist, however, for the accommodation of single Officers or Warrant Officers.

(d) *Housing Estate*

Situated in Milton of Campsie, about two miles from the Range. At present comprises:

Married Officers houses	4
Married Soldiers houses	3*
Civilian staff houses	11*

*Same type of house in the same area.

(c) In 1972 - 74 the South of Scotland Electricity Board and Central Electricity Generating Board carried out a large number of explosive tests on pulverised fuel pipeline components in the open area in the North part of the range. The Ampex Tape Recorder and other range facilities were found to be ideal for this type of trial which in no way inhibited the normal day to day gun firings on the batteries. Results from these trials enabled the various Boards to select the most suitable material for their pipeline components, and private firms were able to demonstrate the quality of their castings.

(f) *Local Relations*

Local relations are good. Some complaints of minor damage to ceilings, greenhouses, etc., arise. All claims are handled by SDLA, Scottish Region. A number of articles, complaining of the noise of gunfire, do, from time to time, appear in the local Press.

New 20 Watt Travelling Wave Tube

English Electric Valve Co. Ltd. has added a 20 Watt, 10·7 to 13·2 GHz Travelling Wave Tube to its range of power TWTs for wideband communication systems.

This type N1093 is a high efficiency tube with an integral periodic permanent magnet focusing system and is packaged in a conduction cooled mount with waveguide r.f. connections.

The N1093 has been designed for simplicity of installation. It is supplied with either an integral or a separate heat sink and is pre-tuned during manufacture to eliminate matching and focusing adjustment. Installation or replacement operations have been reduced to disconnection and reconnection of the fixing bolts, supply leads and waveguides.

The gain, noise factor and AM/PM conversion are compatible with 1800 channel multiplex system requirements.

SHIP AND MARINE TECHNOLOGY REQUIREMENTS BOARD

DEPARTMENT OF INDUSTRY

A Consultative Note on the Framework for R and D

Ship Technology

The Board's policy for R and D support for the ship production industry stems from the view that a healthy and competitive industry can be achieved. This is likely to continue to be based on a wide mixture of ship types, but with each shipyard identifying more clearly the limits of its own range of products The industries involved, including the ship repair industry, should take advantage of the rapidly growing market for work in support of offshore activities; shipbuilders and repairers have a major contribution to make here. In this respect, and in relation to marine R and D as a whole, the interests of shipbuilding, ship operating and marine technology generally are one. In relation to ship repair, while the Board has no specific R and D proposals, it would like to see an assessment of the need for a UK repair and casualty facility for very large ships.

Ship Building

(a) *Design*

The programme of R and D inherited by the Board was largely directed towards improving ship hull design capability; and it is considered that much of this work is still relevant and should continue. Because of changes in the price of fuels, and because of a continuing concern and need to try to reduce the first cost of ships, work on ship hydrodynamics and structures will continue to be important. However, the Board is seeking to define more clearly the objectives and potential benefits of this work. It is concerned to ensure that the teams and resources which have been built up in these areas of research should be used to best advantage and that particular attention should be paid to the problems which continue to arise in connection with hydrodynamic performance of ships and their structures: many of these cannot be solved without R and D. An aspect of ship design for which research is being given high priority, concerns the causes and cures of excessive noise and vibration, particularly in fast and full-form ships. In this context, as in other aspects of design there is a need for more full-scale performance data, in order that uncertainties in extrapolating from model scale can be reduced.

(b) *Market research and assessments*

Although R and D in support of design will continue to be important, the Board considers that industrial competitiveness will benefit from some increase in R and D activity in two other areas which hitherto have received rather less support. The first area embraces market research and assessment studies. Market research has tended to concentrate on the oil and major bulk trades, whereas half the U.K. shipbuilding output has been of minor bulk, general cargo and other ship types. Very little research into the future demand for these latter ship types has been done. In the past, market and operational research has been left to commercial interests, but the Board believes that it could play a part in improving the competitiveness of British industry by investigating future demands and needs, and suggesting how these could be met.

As regards assessment studies, the Board is aware of a number of interesting ideas and technical developments which might find eventual application in marine transport. It is important that techno-economic assessments of such ideas should be carried out in the light of changing economic, fiscal and trading factors, so that promising concepts can be identified early, and industry alerted to them. Similarly the Board intends to keep under close review the changing prospects for the marine use of nuclear power. Together with technical assessments, it will encourage close examination of legislative and safety aspects of nuclear propulsion,

The Board proposes also to examine ways in which innovation might be further encouraged, particularly in relation to the full-scale use of new systems for the propulsion, manoeuvring and control of marine vehicles.

(c) *Production*

The second main area of R and D to which the Board accords high priority is directed towards improved production efficiency. The Board recognises that certain aspects such as labour relations and capital investment, which have major influences on productivity, are outside the scope of its R and D remit, but it considers that its work can interact beneficially with these aspects, and that labour relations can be greatly helped by appropriate capital investment backed up by research and development. The Board therefore attaches importance to the study of environmental factors affecting shipbuilding, and the study of advanced shipbuilding techniques and facilities, and to the development of methods of optimising the returns on existing and future capital investment. The Board also sees a need to promote the U.K. capability in marine equipment and shipboard systems and where possible it wishes to encourage the provision of systems packages. Ways of using computers and automation more effectively in support of design and production are also important and the Board is currently supporting BSRA work with that aim.

(d) *Other Areas*

Our discussions with marine industry have shown two other areas of work to be particularly important:

improvement of the suitability for purpose and the reliability in operation of marine equipment and systems

study of the implications for ship and offshore work of impending and possible changes in statutory regulations and legislation.

In these areas as in other aspects of marine R and D, the Board is anxious to encourage more effective interaction and co-operation with other government departments such as MOD(N) and it is keen to secure the release of non-classified R and D for the benefit of industry.

Ship Operation

The important areas of R and D in this sector are concerned with the manoeuvrability of ships, safety of ships at sea, cargo handling in all its aspects, ship propulsion having implications in the operating field; and training, an area in which the Board has already awarded a contract for a nocturnal ship simulator.

Marine Technology

The Board accepts that there is a very good chance that in 1980 we can produce oil equivalent to our demand, but it has to be recognised that these supplies will not last forever. Like the Joint Industry/Government Working Party on which we are represented, and whose interim report has recently been issued, we believe the national objectives should include the development of a U.K. capability to extract hydrocarbons from progressively deeper waters. The aims of the Board in the field of marine technology are therefore:

(i) to support R and D that will lead to safe, rapid and continuing exploitation of North Sea resources.

(ii) to support R and D that will facilitate the search for new hydro-carbon reserves around the U.K.;

(iii) to secure data on seabed and marine engineering which will help the statutory functions for the safety of offshore installations as well as provide data required by industry for the design of structures and equipment.

(iv) to support R and D that will help foster the U.K. potential to compete in manufacture and service in the world-wide offshore market.

Current concern is with oil and gas recovery in depths down to 200 m., and we are now examining prospects for much greater depths. We believe that in general it is not feasible for industry to go immediately for the development of technology for greater depths without

first creating a recognised commercial capability employing current techniques in depths at which operations are being undertaken at present. But carefully selected R and D now could help pave the way as the industry operates at greater and greater depths.

In connection with structures suitable for current North Sea depths continuing work will be required for some time to come on acquiring basic data about offshore conditions, weather, wind, waves and currents and seabed conditions, soil mechanics etc. R and D connected with deep seismic survey and water depth measurement may be needed. The promotion of additional R and D into diving and submersibles is under examination at present.

The Board is in general accord with the specific recommendations of the interim report of the Joint Industry/Government Working Party that technological developments should be encouraged in the following areas:

Buoyant platforms, pipelaying and burying techniques, offshore storage and tanker loading systems, anchoring and mooring systems, underwater working, including submersibles, diving, repairs, underwater tools etc., self-contained oilfield seabed systems, *i.e.* self-contained enclosed systems for the extraction and primary treatment on the seabed and transportation of oil and gas and installation of platforms and equipment offshore.

The Working Party noted that industry has the major part to play and that the Government financed programme on R and D is complementary to what industry does itself.

The Board has noted the proposals of the Working Party for the further development of methods, plant and equipment which would extend the effective weather window and also the development of the organization and techniques needed for comprehensive inspection and maintenance of offshore installations and associated equipment.

The Board has already initiated work in many of these areas and will be considering in the following months, particularly in the light of the reaction from industry, how best R and D can be promoted in this field. Readers are invited to send comments to: G. S. Stewart, Executive Officer, Department of Industry, Abell House, John Islip Street, London SW1P 4LN.

Nuclear-Powered Submarine Launched

H.M.S. *Superb*, the ninth nuclear-powered Fleet submarine to be built for the Royal Navy, was launched at Barrow-in-Furness on Saturday 30 November by Mrs. David Williams, wife of Admiral David Williams, Chief of Naval Personnel and Second Sea Lord.

Superb, which is being built by Vickers Shipbuildng Group, is the third of the latest *Swiftsure* class. Vickers built her predecessors, *Swiftsure* and *Sovereign*, and five of the other six Fleet class submarines.

Superb will have a displacement of 4,400 tons on the surface, with a length of 272 feet and a beam of 32·3 feet. Her maximum continuous underwater speed will be in excess of 20 knots, and she will have a totally-submerged endurance of several weeks.

She will be commanded by Commander David Ian Ramsay.

Vickers Oceanics take over most advanced Support Ship

Vickers Oceanics Ltd. of Barrow-in-Furness, have taken delivery of their third submersible support and oceanographic survey ship, the *Vickers Viking*. The vessel has been delivered after conversion by Manchester Drydocks Ltd. (formerly Manchester Marine), with whom Vickers Oceanics have now placed a further contract for the conversion of a fourth ship for operation in coastal waters.

Built by A. G. Weser at their Bremerhaven shipyard in 1965, *Vickers Viking* was originally the *Hamburg* and was later re-named *Dortmund*. She was purchased by Vickers Oceanics Ltd. in February and is 235 feet long, has a beam of 44½ feet and a draught of 18 feet. She displaces 3,110 tonnes. A Deutz V-12 diesel engine developing 3,000 b.h.p. gives her a speed of 15 knots.

The ship's facilities have been radically changed so as to provide additional accommodation and the workshop, hangar and other facilities essential to the efficient operation of the *Pisces* and *Perry* type submersibles operated by Vickers Oceanics. She is equipped with a built-in underdeck decompression chamber with mating facilities for diver lock-out submersibles, which will enable it to undertake—in conjunction with Oceaneering International Ltd.—diving operations down to 1,000 ft. A second chamber is to be fitted later. The ship also has four-point mooring for maximum precision in positioning during operations.

With *Vickers Viking*, Vickers Oceanics will provide an entirely new service to the offshore industry. Having diver lock-out submarines, divers provided by Oceaneering International in a joint venture, will be taken to the bottom by submersible; be able to swim free, and, after the completion of their work, be able to re-enter the submersible and return to the mother ship for transfer to a decompression chamber. Alternatively a diver can be held under saturation conditions for the next dive.

The Vickers-developed submersible handling system fitted in the *Viking*, has an increased over-stern lifting capacity of 50 tonnes. As with the other ships in the VOL fleet, ship/sea motions are automatically compensated for by a special winch, and submersibles can be launched routinely in conditions up to sea state 6.

Vickers Viking has accommodation for 46 people, including the ship's company and submersible and diving personnel, plus representatives of the charterers if they are required to be aboard. The ship's crew totals nine officers and 25 men, and the vessel is commanded by Captain Len Edwards, whose home is near Cardiff, and who has been in command of *Vickers Venturer*, the company's first support ship, and has acted as relief captain aboard *Vickers Voyager*, their first deep sea vessel.

Equipped so as to be able to operate for one month without shore support, *Vickers Viking* will follow *Vickers Voyager* into deep sea service. She will commission at her home port of Barrow-in-Furness before sailing to Leith for the opening of Vickers Oceanics' new base there and then taking up duties in the North Sea.

NOTES AND NEWS

Admiralty Underwater Weapons Establishment

Mr. L. F. W. Simmons, SSO retired in October 1974 after 38 years' service.

Len (left in photograph) started his working life in a tool room making tools for the manufacture of sparking plugs. He joined ARL at Teddington as a mechanic in 1936 and quickly earned a reputation for accurate work. Some six years later he entered the drawing office and carried his reputation into design work associated with aircraft predictors and VSG's for the BOFORS gun. During this period Len played football for Molsely and NPL.

He joined the scientific group at ARL in 1946 and later AGE, moving to Portland in 1954 where he worked on Directors under Commander Golby. With the transfer of TEE, UCWE and ULE to Portland in 1959, Len joined the newly formed Torpedo Division to apply his design knowledge to ONGAR, later to become the MK 24 Torpedo. His meticulous attention to detail and a stubborn refusal to be deflected from what he knew to be right have made a very significant contribution to the soundness of his designs. He remained up to his retirement in the field of torpedo research and became an authority on structural aspects of torpedo design.

Len was a quiet, unassuming, serious minded person who got on well with everybody. At his retirement, his colleagues presented him with a transistorised clock, a pair of secateurs, and a mounted propeller blade to remind him of his 15 years' work on torpedoes. All his friends and associates wish him and Mrs. Simmons a long and happy retirement.

The Lord Lieutenant of Dorset, Colonel Sir Joseph Weld, O.B.E., T.D. (second from left) paid a short visit to the Admiralty Underwater Weapons Establishment, Portland on Tuesday, 8 October. He was briefed on the Establishment's work, was conducted around AUWE Southwell, and finally toured RDV *Crystal* in Portland Harbour.

The Controller of the Navy, Admiral Sir Anthony Griffin, K.C.B. visited the Admiralty Underwater Weapons Establishment at Portland on Friday, 1 November 1974, to see the work of the Directorate of Underwater Weapon Projects. During the visit he had discussions with Mr. S. E. Shapcott, Director of Underwater Weapon Projects and members of the staff. The photograph shows the Controller of the Navy being shown the Mine Countermeasures Laboratory by Mr. H. Hudson, Assistant Director of Underwater Weapon Projects, during a tour of the Establishment.

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Naval Construction Research Establishment

The 1974 meeting of the British Association was held at Stirling University. While this year discussions concentrated on numerous aspects of medical research a wide range of other topics were covered. On September 3 some 25 - 30 people attending the meeting visited NCRE and discussed the work of the Establishment with the Superintendent and the relevance of its role on structures to North Sea oil exploration.

On 24 September 1974 Mr. K. G. Evans, Assistant Director of Naval Construction and Superintendent of NCRE since May 1968 left to take up a position as the Assistant Director Design Constructive 5 at MOD(N) headquarters in Bath. It was on this same day that Mr. J. F. Coates, ADNC, for a number of years in Forward Design, officially took up his new duties as Superintendent at NCRE.

On 17 September, the DSAC Field Committee (Chairman Professor J. Caldwell) visited the Establishment. Discussions took place on NCRE's future programme in the fields of underwater explosion effects and of structural transmission of noise in the context of submarine design.

Alastair Thomson, a native of Dumbarton and the son of a newspaper proprietor, received his early education at Dumbarton Academy and Glasgow University graduating with honours in Electrical Engineering in 1938. After a short period at Barr & Stroud and Metro Vickers he joined British Thomson Houston Co. as a Graduate apprentice, where he worked on the Whittle gas turbine impeller, until just after the outbreak of the second world war. It was at this time that he met his wife Phyllis.

In 1939 he was appointed Temporary Experimental Officer at the Royal Naval Torpedo Factory, Greenock (the scientific side of which was to become TEE in 1946). His first job at the torpedo factory was to deduce the performance of a number of electric torpedoes salvaged from Scapa Flow after the successful attack on the *Royal Oak*.

Later in his career he became project officer for several British torpedo developments (Mark 11 Electric, Mark 20 electric homing, Mark 23 electric wire guided homing) which produce weapons accepted for Naval service.

He was promoted to SPSO in 1959 and soon after became Head of the Torpedo division in the new amalgamated " Way ahead " underwater establishment at Portland—a position he held until 1963. At this time after 25 years in torpedo development he transferred to NCRE where he became head of the Materials Group; a position he held until his retirement in September 1974.

In his 10½ years at NCRE he has been involved in persuading the British Steelmakers to improve the cleanness of high strength alloy steel for submarine construction. On his arrival at NCRE in 1964 the problem of cleanness in submarine steels was of paramount importance. He brought his considerable experience to bear on this new problem and now with the application of modern steelmaking production techniques the British Steel industry is competitive with any in the field of clean steels.

He is now retiring to Helensburgh on the Firth of Clyde, an area with which the Thomson family has long been associated. He will maintain his Civil Service connections as a Civil Service Commission Chairman. His other interests will include assisting his son-in-law with a travel and estate agency business and curling. He and his wife are keen curlers, Alastair being an " inter city " curler of note.

Alastair lays claim to the world record " sitting high jump " for which he qualified during the examination of a torpedo pistol firing mechanism onboard the captured U570. On this occasion whilst sitting astride the torpedo, someone dropped a large spanner on the steel deck, whereupon Alastair's reactions took over. It is indeed unfortunate that no one had the presence of mind to measure the jump and thus verify his claim.

Alastair Thomson has always been known and respected as a man of principle and integrity. He has been particularly anxious to ensure that young scientists are encouraged to develop their particular aptitudes, and has also been sympathetic to their problems. By his example he engendered a spirit of technical honesty and true scientific endeavour, insisting that all work should be properly recorded and written up. His contributions to Naval Science are widely recognised not only in the UK but in Europe and the USA. It is in these respects that his colleagues will value their association with him as a scientist and friend.

It is the wish of his colleagues that he has a long and happy retirement with his wife and family. Hopefully he will find ample opportunity to use the telephone table presented to him by his colleagues at NCRE and AUWE in order to speak to his old friends.

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Admiralty Surface Weapons Establishment

Dr. D. C. Tyte, P.S.O., who has been working on lasers at the Services Electronics Research Laboratory at Baldock has now joined the establishment's Assessments Division. Mr. W. R. Carter, P.S.O., has returned to the establishment following a tour of duty with Specialists Personnel Management Division (SPMI), and his place at headquarters has been taken by Dr. J. Preston of the Admiralty Compass Observatory. Mr. T. C. Grainger, S.S.O., has joined A.S.W.E. from the Management Computers Division (Man C5) and is now working for Director, Surface Weapons Projects (Naval).

Mr. D. M. L. Bartholomew has joined the Navigation Division at Ditton Park.

Mr. D. G. Appleby, a lecturer on the staff of the University of Southampton, has joined the establishment for one year as a Principal Research Fellow and is working in the Action Information Organisation Division.

Mr. K. G. Hambleton, P.S.O., attended the fourth European Microwave Conference at Montreux in September.

A number of senior officers including Dr. J. W. Berry, S.P.S.O., Mr. J. V. Hubbard, P.S.O., and Dr. R. J. Tunnicliffe, S.S.O., recently visited the SHAPE Technical Centre for discussions on radar display techniques.

Mr. R. J. Poole, the Head of the Assessments Division is at present attending the Senior Officers' War Course at the Royal Naval College, Greenwich. In his absence Mr. D. N. Keep is Acting Head of the Assessment Division and Mr. Keep's own post as Head of the Planning and Resources Division is filled temporarily by Mr. K. V. Watt.

First Sea Lord at A.S.W.E.

The photograph above, showing left to right Captain R. E. de M. Leathes, R.N. (Captain Surface Weapons Acceptance), Captain R. G. A. Fitch, R.N., Commodore L. S. Bryson, B.Sc., C.Eng., F.I.E.E., F.R.Ac.S. (Director Surface Weapons Projects), Dr. D. H. Davies (Head of A.S.W.E.'s Weapons and Sensors Research and Support Department), Sir Edward Ashmore, G.C.B., D.S.C., A.D.C. (First Sea Lord), Mr. C. P. Fogg, C.B., M.A. (Director of A.S.W.E.), Dr. J. W. Berry (Head of A.S.W.E.'s Computers Division), Mr. B. N. C. Amos (Head of A.S.W.E.'s A.I.O., Trainers and Data Links Division), Captain I. S. MacCillivray, R.N. (Director of Naval Operational Research) was taken on Friday 22 November, on the occasion of the visit of the First Sea Lord to the main establishment at Portsdown. During the course of his day's visit he was given up-to-date insight into the establishment's current commitments in such fields as communications, guided weapons and surveillance radar.

Obituary

With the untimely and sudden death of **Dr. Milwyn Bound** on 22 October 1974 A.S.W.E. has lost one of its most respected scientists.

Born of a mining family in Blaengawr in Glamorgan during 1911 he studied Chemistry, and later Physics, at the University of Wales, eventually being awarded a Doctorate of Philosophy for his thesis on " The Application of Electron Defraction to the Investigation of Surface Corrosion " in 1938. Later he undertook further Post Graduate Research at Manchester University on " Pulse Amplifiers and Short-Wave Receivers for the Chain Station Radars ".

Known as " Doc " to most of the staff, Dr. Bound joined the Signal School at Portsmouth in 1939 and worked in Dr. Smith's Group on Infrared Systems. Later at Haslemere and Witney he joined NX and GX as part of the team developing the Navy's first Guided Weapon System SEASLUG, where, with Mr. Boronski, he helped to effect the first high-powered ferrite isolator to be used by the Royal Navy, significantly contributing to the success of that project.

He was selected by Mr. D. S. Watson, then the Director of A.S.W.E., as the leader of a newly formed Assessment Division, where he was responsible for building up a successful group to analyse the performance of the Establishment's future projects as well as fully developed systems.

Promoted to S.P.S.O. in 1956 he led this team up to the time of his formal retirement in 1971 when, in view of the acute shortage of experienced assessment staff, he was invited to stay on in a dis-established capacity where he remained until the time of his death.

In his private life " Doc " was a devoted family man with a Welshman's passion for music. A competent musician himself in playing both the piano and organ, he was particularly fond of both Bach and Chopin, whose works he had studied deeply.

To many of the senior staff at A.S.W.E. and elsewhere he was a personal friend of many years standing, while for the younger members of the Establishment his approachability and helpful advice made him a very popular figure.

The whole Establishment mourns his passing and shares with his wife and family the sorrows of their loss.

BOOK REVIEWS

Theoretical Nuclear Physics. Vol. 1. Nuclear Structure by Amos de Shalit and Herman Feshbach. John Wiley & Sons, Inc. pp. 979 + XXVIII.

Amos de Shalit died in 1969. He was one of the very few scientists who engaged in both theoretical and experimental nuclear physics research. He became involved in experimental physics at the Institute of P. Schemar in Zurich, and later turned to theoretical work during his years at Princeton University and M.I.T. Perhaps his most outstanding contribution to Nuclear Physics literature was the " Nuclear Shell Theory " with I. Talmi. Professor de Shalit was able to finish most of his contributions to " Theoretical Nuclear Physics " before his death and Herman Feshback welded the pieces together into an impressive work. As Victor Weisskopf says in the foreword:

> " The achievements of nuclear research of half a century are described here in a concise, systematic and lucid form ".

The present book on " Nuclear Structure " is the first of two volumes intended to describe the fundamental principles underlying the present understanding of nuclear structure and interactions. The second volume is not yet complete but it will be concerned with two subjects. The first will focus on nuclear forces, their origin in the exchange of bosons and their manifestations in nucleon-nucleon scattering and binding, as well as in the three and four body nuclear systems. The second will be concerned with nuclear reactions and will include reactions induced by high energy particles, direct reactions, transfer reactions, compound nuclear resonances, doorway state resonances, and the statistical theory of nuclear reactions. Reactions involving electromagnetic probes such as electrons and photons, weak interaction probes, the various neutrinos as well as those induced by strongly interacting projectiles such as pions, kaons, nucleons and antinucleons, deutrons, alpha particles and finally heavy ions will be discussed.

The present volume begins with an introductory review of nuclear physics. This is followed by chapters on the Fermi gas model, the properties of nuclear matter, and independent particle models for finite nuclei. Chapter five gives a detailed discussion of the nuclear shield model and chapter six deals with rotational states in deformed nuclei and other collective models. The remaining chapters cover multinucleon systems, electromagnetic transitions and the weak interaction. All of the topics are covered in considerable mathematical detail but the authors have made every effort to " soften the mathematical blow " by including additional semiqualitative discussions where possble. It is this aspect which makes this book particularly readable, especally to the experimental nuclear physicist. Another pleasing aspect of this volume is that the authors have attempted where possible to compare the experimental situation with the predictions of the various theoretical models discussed. They also include some problems, although the teaching value of these is somewhat diminished since they are dispersed throughout each chapter rather than appearing in a definite section at the end of the chapter.

In conclusion, I found this volume on nuclear structure to be a most lucid and readable work and I look forward eagerly to the publication of Volume 2. The complete book will undoubtedly become a standard reference work for both experimental and theoretical nuclear physicists and should be especially valuable for post-graduate research students in nuclear physics.

S. A. Harbison

Low Temperature Laboratory Techniques, by A. C. Rose-Innes. Pp. xiii + 255. The English Universities Press Ltd. Second Edition 1973. ISBM 0/340 17143 X. Price £3·95.

As the author states in his preface his present book is based on his earlier work *Low Temperture Techniques,* now made out of date by the considerable advances in the field over the last ten years. At the time of the writing of the original book, low temperature techniques were essentially confined to the research laboratory, today they are entering the practical engineering world at a rapid pace.

Professor Rose-Innes has taken cognizance of this aspect and includes a suggested introductory reading of the book for a beginner—a useful feature.

Chapter 1 comprises a short introduction of two pages to the subject, mainly on the use of various gases as coolants and finishing on the use of helium.

Part I of the book is devoted to cooling down to temperatures of 1K. Chapter 2 opens the account by considering methods of storage and distribution of helium, with practical suggestions. Incidentally the insertion of a small black disc before and after a section, indicates it may be omitted at a first reading. At the end of the chapter is to be found details of purity testing and gas purification; followed, as are all the later chapters, by a list of references.

A long chapter on cryostats and the design of apparatus follows. It includes, surprisingly in view of the Part I heading, a simple cryostat to reach temperatures *below* 1K. Sections on sorption pumps, pre-cooling, manipulation of liquid helium, design of electrical equipment, methods of taking electrical leads through temporary and permanent gas-tight seals, a discussion on super-fluid liquid helium below 2·2K which allows serious leaks because of its negligible viscosity, materials for use in constructing equipment, etc. is included. The chapter is rounded off by a simple mathematical treatment on the calculation of heat conduction, methods of introducing mechanical motion inside cryostats, and finally ends on superconducting electromagnets.

Measurement of low temperatures is covered adequately by Chapter 4, again with practical hints, suggestions, and construction methods. Such methods as noise thermometry, critical field thermometry, acoustic thermometry, paramagnetic thermometry, etc. are discussed; with a useful table of known temperatures from physical constants.

Control of the selected low temperatures by various methods is fully discussed in Chapter 6 and includes an electronic circuit for fully automatic control.

Part II of the book is concerned with temperatures below 1K, mainly by the use of Helium^3 (the light helium isotope with a boiling point of 3·2K, and the great advantage of being a "normal" liquid down to at least 0·008K!). The alternative adiabatic demagnetisation techniques are not discussed, because of the complexity of the equipment required. Helium dilution cooling down to a few mK is explained, followed by details of handling and methods of Helium^3 dilution. The chapter closes on cooling by solidification of helium down to about 2mK.

Temperature measurements below 1K demand different techniques, again adequately described in Chapter 7, including nuclear orientation thermometry down to 2mK.

The final chapter includes useful data, charts, tables, etc. which should be useful to a worker in this field. An appendix is helpful in providing a list of addresses of suppliers of materials, components, and equipment; together with a useful working index.

Written in an extremely clear style, making its contents easily assimilable, leads one to wonder if the apparent simplicity is achieved by neglecting the treatment of the subject in those parts where the reader might have to use his corragutor, but the book does seem to have the right sort of approach for someone just starting in the field as well as for those with more advanced knowledge of the art. There is no doubt that the use of super-conductivity is destined to require even wider uses of low-temperature techniques and this book is eminently suitable to bridge the gap betwcen the would-be worker and the subject.

All the illustrations in the text are line diagrams, there being only one half-tone illustration, the frontispiece, which is evidently a souvenir of the author's sojourn as a senior member of SERL up to 19 July 1964, the year of the first edition of his book. The first edition was reviewed in *JRNSS* Vol. **20,** No. 2 (March issue) by A. R. Ashmore.

An excellent book in every way and well recommended to all with an interest in low temperature techniques. The reviewer found it quite fascinating to find how close to some of Nature's limits Man has succeeded in reaching, unless such things as negative temperatures are discovered. **C. K. Aked**

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Personal items are shown in *italics*. Names of authors in **bold** type.

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NOTICE TO READERS

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Title: Journal of the Royal Naval Scientific Service
Covering dates 1974 Nov 01 - 1974 Nov 30
Availability Open Document, Open Description, Normal Closure before FOI Act: 30 years
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